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timber trends

in Western Oregon and Western Washington

PACIFIC NORTHWEST
FOREST AND RANGE EXPERIMENT STATION
U. S. DEPARTMENT OF AGRICULTURE

U. S. FOREST SERVICE
RESEARCH PAPER PNW 5

OCTOBER 1963

U. S. Forest Service Research Paper PNW — 5

October 1963

TIMBER TRENDS IN WESTERN OREGON AND WESTERN WASHINGTON

by

Division of Forest Economics Research

PACIFIC NORTHWEST

FOREST AND RANGE EXPERIMENT STATION

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FOREST SERVICE

U. S. DEPARTMENT OF AGRICULTURE

FOREWORD

This study of timber trends in the Douglas-fir region was undertaken in response to increasing public concern over the situation and outlook in the Pacific Northwest forest economy. Its objective is a long-term appraisal of timber supplies in the Douglas-fir subregion of western Oregon and Washington. The appraisal is made by examining the outlook for supplies of timber available from each of the major groups of ownership. Recognition is given to the effect of economic and technical factors such as the level and objectives of management, economic influences bearing on different classes of forest owners, present forest conditions, cutting practices, and potential productivity of the forest lands of the region.

The entire staff of the Division of Forest Economics Research participated in the very considerable tasks of formulating a basis for analyzing the supply situation, contacting public and private landowners and managers, and projecting the complex forest resource into the future. The authors of the study were able to draw freely from the most recent Forest Survey inventory information—detailed information which had not previously been analyzed.

The Forest Service has made numerous appraisals of the national timber supply situation in the past, but there have been relatively few analyses of regional situations. This one is unique in that it analyzes in depth the economic factors expected to control or influence timber supply in various classes of ownership. This has been done by building an economic model for explaining and estimating timber output in the region.

The model used in this study is concerned primarily with the long-range level of output that might be expected under the long-term influence of various economic forces. Short-run considerations such as impacts on prices and profits of alternative cutting policies have not been included in this analysis. Also, the study assumes economic objectives for Federal and other public forest ownerships comparable to those of private owners. In practice, it may be desirable to temper local objectives by broader considerations such as the impacts of Federal cutting and management policies on the total level of employment and on the stability of economic activity in the region.

Various assumptions have of necessity been made in developing estimates of rotation age, for example, and estimates of prospective timber output on various classes of ownership, including assumptions as to the appropriate guiding rates of interest for different owners, a highly elastic demand for timber products, and a long-range increase in prices for the young timber that is expected to be available in future years. While use of different assumptions for such items would result in somewhat different conclusions, it is believed that the model and the assumptions adopted in this study serve well the purpose of examining the de-

terminants of timber supply and the prospects for longrun timber supplies in the region.

The statements and conclusions in this report are not presented as direct recommendations for policy or program revisions, public or private. An attempt has of course been made to carry out this analysis within a framework of existing and anticipated factors, both economic and noneconomic, which must be taken into account in establishing goals and policies.

The outlook for timber supply in the Pacific Northwest is a timely and important subject. We believe that systematic studies of this sort will lead to improved understanding and to sounder decisions concerning the problems of managing our Nation's timber resources.

Carl A. Newport, Chief
Division of Forest Economics Research

SUMMARY

The purpose of this study is to assess the influences upon timber output in the Douglas-fir subregion, the potential timber supply in the long run, and the problems of reaching the potential during the conversion of an old-growth to a young-growth timber economy.

An economic model is developed to account for the major factors influencing timber output. One factor is the management practices followed on the forest lands. Another is land use—the acreage and quality of land allocated to timber growing. The third influence upon output is bound up in the time element as expressed in the guiding rate of return on forest investments.

Management intensity is classed as intensive (or conservative, intermediate, and exploitive (or extensive)). The study shows that the intensive or conservative owners tend to hold relatively large investments in growing stock and that such investments involve relatively low guiding rates of return, that is the rates of interest at which forest owners compound or discount values. On the other hand, exploitive-type owners make relatively small per acre investments and, in effect, have a high guiding rate of return. Determinants of guiding rates, such as availability of alternative investments, fringe benefits, risks and transfer costs, and characteristics of different owner classes, are indicated.

The economic model is used to demonstrate the considerable influence that the interest cost of building up or holding of growing stock has upon total output, primarily through its effect on length of rotation. Management costs and timber revenues are also examined with particular attention to the bearing of each determinant upon an owner's incentive to grow timber. The model demonstrates, for example, how lower conversion costs per unit of volume with advancing size and age of trees tend to influence rotation age. Other factors such as regeneration costs, quality differentials, timber value trends, and costs of timber stand improvements and fertilization also are analyzed in terms of impacts on rotation age and on the total output that may be expected from various types of owners.

In order that potential timber output in the region could be estimated, the influence of land use and land ownership also has been considered. Currently, 73 percent (25.8 million acres) of the 35 million acres of land in the Douglas-fir subregion is classed as commercial forest land, suitable and available for timber production. Under the land-use assumptions adopted in this study, this is reduced to 24.8 million acres by the year 2000. About half of this decrease of 1 million acres of commercial forest land is expected in public holdings and half in private. The reductions in each class of public holdings are expected to occur in proportion to the total amount in each. Both reductions and major shifts in ownership of commercial forest land are expected to take place in the three size classes of private holdings. Large holdings are assumed to increase from about 5.4 million

acres to 8.8 million. Medium-size holdings are assumed to drop from 1.7 million acres to 0.8 million. Small-size holdings are expected to drop from 6.1 million acres to 3.1 million.

After the various economic influences upon timber output and prospective land use are examined, estimates of the annual yields of timber that might economically be produced in the Douglas-fir subregion in the long run are next derived. For each class of owners, i.e., conservative, intermediate, or exploitive, guiding rates of return are assigned: 3, 6, and 12 percent, respectively. Economical per acre yields are estimated for each class of forest owner and for each forest type and site. The per acre yields estimated under the specified assumptions are then applied to the expected land use and forest ownership to estimate total annual yields in the long run.

As an illustration of the kinds of assumptions made in this analysis of the long run, take the case of the conservative owner of Douglas-fir site III land managed for continuous saw-log production. An even-aged silvicultural system is to be followed, with light intermediate cuttings beginning early enough in the life of each stand and continuing frequently enough to permit high utilization of the site. Harvest cuts are to be made at a rotation of close to 80 years, with an average breast-high diameter of crop trees of about 22 to 24 inches. After the final harvest cut, prompt regeneration of a good quality stand is to be assured by whatever means are necessary. The forest is to be managed under close professional supervision. It is to be provided with a road network, or equivalent means of access, to a high standard. All trees 6 inches and larger, d.b.h., are to be utilized to a 4-inch top; and losses from fire and other agencies will be held to a negligible level. Increases in unit value of wood are assumed to amount to 1 percent annually due to conversion and regeneration cost differentials. A prospective stumpage value of \$40 (1957-59 basis) per thousand board feet, Scribner rule, is assumed.

On the basis of such calculations, it is estimated that the potential timber output of the Douglas-fir subregion in the long run amounts to an average of 526 board feet per acre, plus an additional 17 cubic feet per acre. The total saw log yield is estimated to be 13.1 billion board feet per year, plus 0.4 billion additional cubic feet per year. This is about 14 percent above the subregion's average annual timber output of 11.5 billion board feet during the decade of the 1950's. More than half of the total potential is attributed to type site 1 (chiefly Douglas-fir and ponderosa pine sites I and II). More than four-fifths is attributed to conservative owners, principally large-scale corporations and the Federal Government.

The effects of several alternative assumptions upon the longrun potential output also have been considered, including alternative price levels, interest rates, and land management and use. It is concluded, for example, that, within a rather wide range, stumpage price levels have but a rather small bearing upon the long-range output and the higher the price, the smaller the bearing of a given amount of price increase.

The guiding rate of interest works upon potential output through all the same influences as does price, and since it exerts an additional effect through its control over growing stock and rotation length, output is considerably more sensitive to the rate of interest than to the price level. Various ways of reducing guiding rates of interest, such as transfers of ownership, are indicated.

Consideration of alternative assumptions with regard to land use and management indicates that such changes as appear possible in the management of small holdings, for example, or the designation of additional public recreation areas would not alter significantly the estimate of long-range timber output in the region.

The longrun potential of 13.1 billion board feet plus 400 million cubic feet per year is in the nature of a destination or target. Since the end of the long run is distant, some may view the target with detachment or unconcern. But the means and the route for reaching the longrun level of production are of immense and immediate interest. Questions of timber yields during the transition period of conversion to a young-growth economy are therefore examined in the final chapter of the report.

Two important timber management tasks of the transition period are pointed out—scheduling the reduction of excess growing stock and achieving a desired distribution of age classes. The longrun estimate of required growing stock in the region under the specified management assumptions is some 203 billion board feet, or an average of 8,200 board feet per acre, Scribner rule, in trees 11 inches and larger in diameter to a minimum 8-inch top inside bark. The present total growing stock is about 647 billion board feet, or an average of about 25,000 board feet per acre to the same standard of measure. The degree of excess growing stock increases as one moves from the better to the poorer sites—largely because this is the general order in which the sites have been entered for exploitation and in which conversion to young growth has progressed.

The problem of distribution of growing stock by age classes is described by comparing the ideal age class acreage distribution with the actual. Stands less than 100 years old occupy 58 percent of the even-aged coniferous commercial forest land in the Douglas-fir subregion. On these lands, stands between 1 and 40 years are most prominent. About 20 percent of the region supports stands of 100 to 250 years, and 14 percent has stands over 250 years of age. Of this 8 percent of the area that is nonstocked, about half is in burns and old cutovers and half in recent cutovers.

To determine what changes are likely to occur in timber output and levels of growing stock if present trends in forest management and timber cutting should continue, detailed projections of timber growth and cut were made by decades to the year 2000 and thereafter to 2060. These projections indicate that the output or cut from all commercial forest lands of the subregion may average about 12.5 billion board feet annually during the 1960's and about 11.6 billion board

feet per year during the four decades 1960-2000. This would be essentially equal to the average of 11.5 billion board feet of annual cut in the decade of the 1950's. The character of the future timber output is expected to change as more of the harvest comes from smaller trees, thinnings, and lesser used species.

Finally, recognition is given to the possibility of modifying the outlook by intensifying forest management more rapidly than is now in prospect and by converting old-growth timber to young growth more rapidly than is now intended. There are many alternatives to the expected trends in output, depending upon cutting policies followed in old-growth stands and the nature and amount of investments in timber management. Accelerated reforestation activities and more rapid development of thinning and relogging, for example, could increase timber yields beyond those indicated in the projections. Accelerated cutting of old-growth timber also could lead to increases in total output of timber products, although at the risk of industrial instability in the region. Studies of such potential modifications of present trends must be the subject of future analyses that will supplement this initial study of the timber situation and outlook in the Douglas-fir subregion.

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Chapter 1

Introduction

The purpose of this report is to throw light on the future of timber growing and timber industry in western Oregon and western Washington. This part of the Pacific Northwest, the Douglas-fir subregion (fig. 1), has been the center of United States lumbering for several decades: Encompassing less than a twentieth of the Nation's forest land, the subregion has been responsible for as much as a fourth of the annual sawtimber harvest. Since World War II, it has become also a center of interest in timber management. Its transition from old-growth toward a young-growth timber economy is well underway.

Questions on the Future

What is likely to be the yield of a young-growth timber economy? How will the yield be affected by competing uses of forest land, particularly recreation? How will it be affected by forest ownership, by timber-management policies and costs, and by timber prices? How will the young-growth yield compare with the vast outpouring of wood that abundant old growth has made possible? How severe will the adjustment be, from an old-growth to young-growth economy? What changes in quantity and quality of timber raw material must wood-using industry prepare for? How fast will the great supplies of Government old growth be liquidated, and what effect will the rate have upon the longrun timber supply? What bearing will public and private forest policies have upon the timber supply situation?

Such questions regarding the future are hard to resolve even though they relate to forests, ordinarily so resistant to time and innovation. Northwestern forests today are at the center of new and sharp changes. Along the western slopes of the Cascade Mountains, one may drive to timbering operations on ground that only the "day before yesterday" was untouched and unseen, a part of the timeless virgin wilderness. Foresters look to the possibility of tending and harvesting such tracts by air, a development that could place the timber under intensive management almost overnight. Before some areas are harvested, materials, manufacturing methods, and ways of life unknown today will greatly affect the timber value. Within a generation, the changes of a thousand years and more will come to bear on some of these forest lands.

Despite the uncertainties, it is judged useful to peer into the future. The course of forestry and wood industry has a direct, large influence on the well-being of nearly everyone in western Oregon and western Washington. Furthermore, the prospect for one of the Nation's chief wood-producing areas is clearly of national interest.



Figure 1.—Three districts of the Douglas-fir subregion of the Pacific Northwest.

Any study of the future must be rooted in the past. The historical foundations for the present study are described briefly here in chapter 1. Then in chapter 2 the influences upon timber output are analyzed: specific influences on the timber owner, such as costs and revenues, and more general influences, such as land use and the trends in forest ownership. Chapters 3 and 4 take the partly abstract material developed in chapter 2 and apply it to testing the consequences of future developments. The subject of chapter 3 is timber supply in the long run, beyond the era of old-growth conversion, when young-growth forests might be in full production. The subject of Chapter 4 is timber supply during the transition, when such questions as old-growth conversion rate and young-growth rotation length, thinning programs, and utilization are paramount.

Some Early History

Forestry history in the Douglas-fir subregion falls into three eras, separated by the two World Wars.

In the era before World War I, the principal disposition of the public lands was completed. The National Forests were set aside, and the private timber domains of the region were founded. Timber output rose steadily, with the Puget Sound district taking the lead (fig. 2). However, the lumber industry was working mostly close to waterways, and the bulk of forests was being held for future values. Indeed, the pressure of speculative land acquisition was boosting land and timber prices by high percentages, though their level was generally low relative to today's prices.

After the turn of the century came the region's first substantial development in forestry practice, the beginning of widespread forest fire control. Shocked by the great Yacolt conflagration in Washington in 1902 and by later disastrous fires, landowners banded to form protective associations. Establishment of the National Forests brought fire control to these lands. The States strengthened their laws to promote protection. It was at this time also that schools of forestry were started at Oregon State University and the University of Washington.

Inter-War Era

In the second, inter-War, era, the Douglas-fir subregion further increased its timber output. Paced by the Grays Harbor and other areas of the Columbia River district, and with the plywood industry rising to prominence, Oregon and Washington became top States in wood production. The shift of the Nation's forest products center from the South to the West was furthered by the opening of the Panama Canal and by the growth of export markets.

Log, lumber, and other wood-product prices showed a generally declining trend during the inter-War era, punctuated by sharp market crises following 1920 and 1929. "Overproduction" was the cry of the times, growing more shrill and despairing as the era wore on into the decade of the Great Depression. Private owners liquidated wide stretches of standing timber and abandoned much land.

ANNUAL LOG PRODUCTION

BILLION BOARD FEET, LOG SCALE

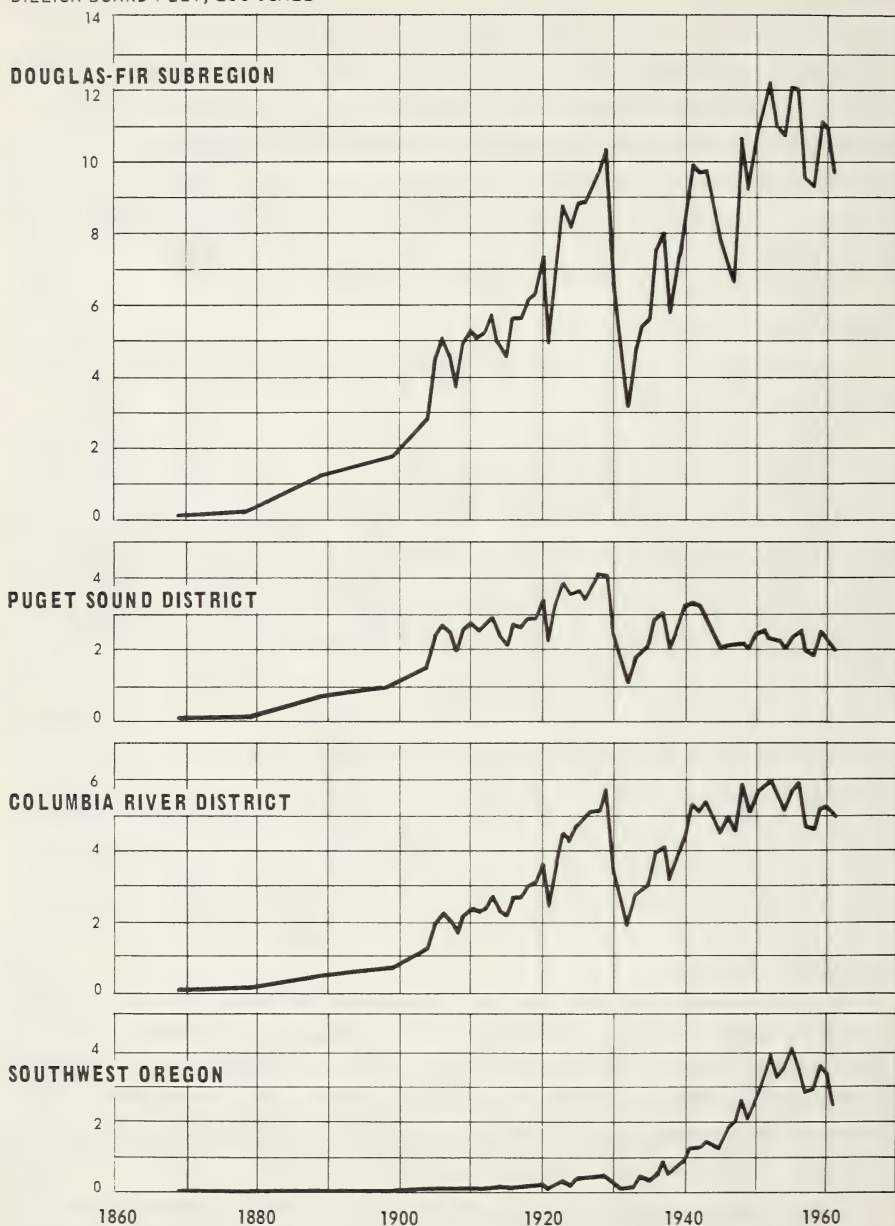


Figure 2.—Annual log production in the Douglas-fir subregion and its three districts, 1869-1961 (decennial data, 1869-99; annual data, 1904-61; production is in terms of log inventory).

From its gravest difficulties the industry harvested some notable gains for forestry. Out of the price and production problems of depression came Article X of the NRA lumber code, which, though short-lived as a legal force, started some industrial landowners on voluntary conservative programs of timber cutting and culture. Much the same basic principles were restated in the forest practice acts passed by both Oregon and Washington near the end of the era. Fire and taxation problems brought the Clarke-McNary law, which strengthened the attack on these problems. To fight "overproduction," industry spokesmen advocated sustained yield, which might prove equally instrumental in keeping output up over the long term as in keeping it down over the short term. Efforts to reduce scale of operations and to cut costs led to changes in logging and to shifts toward truck transportation, which in turn fostered a reduction in size of cutting areas and a start toward development of road networks. Both these changes helped intensify timber management. And out of the melee of timber liquidation and land abandonment came a strengthening of forest ownership throughout the region. Here and there, private firms that survived, and notably some of the big ones, made plans for retaining, restocking, and managing their cutovers.

Current Forestry Developments

The timber-management forces that gathered during the inter-War years are being released in the current era, which began after World War II. The era has three features that are especially significant, all of them closely connected.

One feature is the rapid receding and prospective disappearance of the timber frontier in the Douglas-fir subregion, where more than eight-tenths of all the land is forest and more than seven-tenths is commercial (timber-producing) forest. Wood-using industry is pushing into the subregion's last unexploited block of counties, those of southwest Oregon (fig. 2). The industry is pushing also eastward onto long-inaccessible Cascade slopes and locally into other spots which until recently were remote. In this process, the National Forests, which include almost three-tenths of the subregion's 25-3/4 million acres of commercial forest land and over four-tenths of its standing timber (table 1), have been for the first time generally and rapidly brought into production (fig. 3). The proportion of the subregion's total log output contributed by the National Forests rose from about 4 percent in 1940 to 26 percent in 1961. Finally, the frontier of accessibility of each tree and log has been pushed back. Woods and mill utilization of comparable timber stands has in many cases increased 25 to 50 percent above the amounts that were recovered in the 1930's. Prelogging and relogging have become common. The growth of the pulp industry was particularly helpful to the utilization trend. All these developments have been attended by rapid extension of forest road networks, which in turn have made it possible to step up forest-protection standards.

ANNUAL LOG PRODUCTION from the NATIONAL FORESTS

MILLION BOARD FEET, LOG SCALE

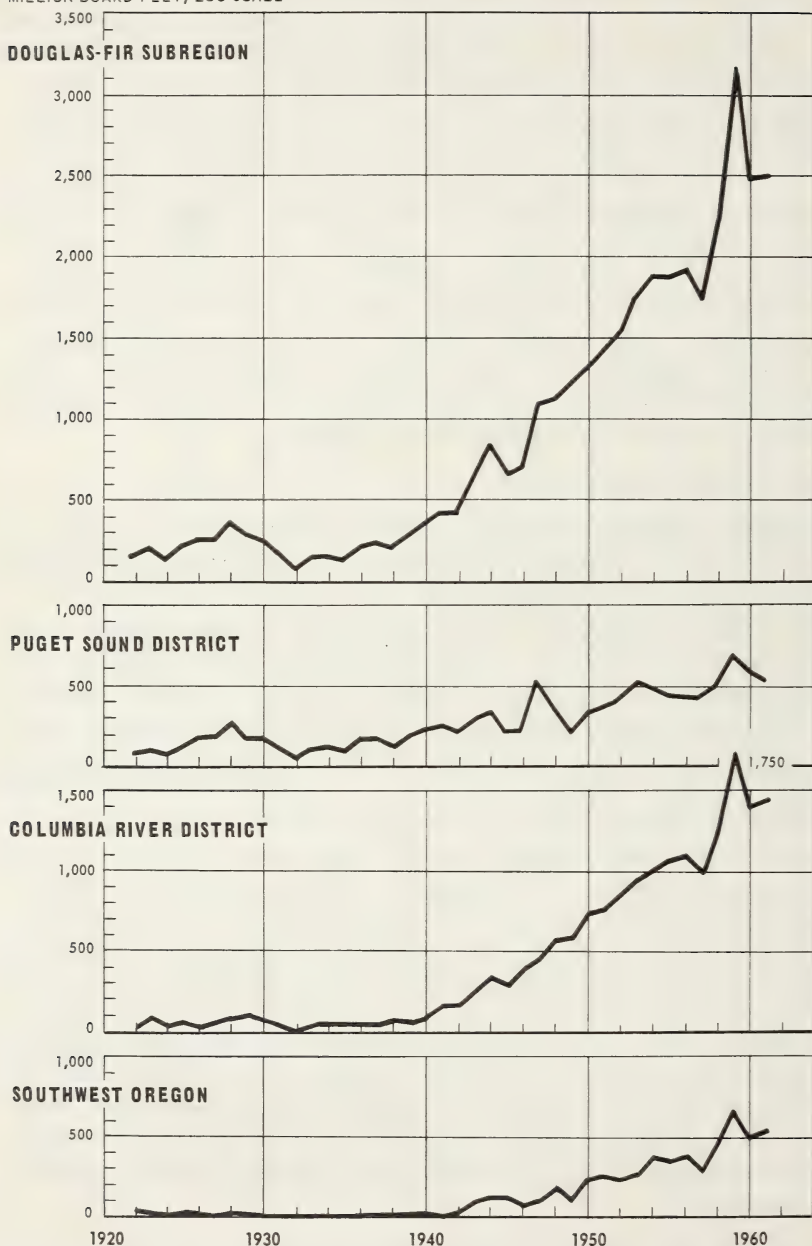


Figure 3.—Annual log production from the National Forests of the Douglas-fir subregion and its three districts, 1922-61 (production is in terms of log inventory).

Table 1. — Ownership of commercial forest land and standing timber in the Douglas-fir subregion and its three districts, decade of 1950's

COMMERCIAL FOREST LAND (THOUSAND ACRES)

District	Private holdings			Public holdings				All Holdings
	Large	Medium	Small	Total	National Forest	Other Federal	Other	
Puget Sound	2,142	363	1,916	4,421	1,745	152	1,063	7,381
Columbia River	2,441	845	2,709	5,995	3,561	882	1,172	11,610
SW Oregon	865	535	1,496	2,896	2,187	1,538	154	6,775
All districts	5,448	1,743	6,121	13,312	7,493	2,572	2,389	25,766
LIVE SAWTIMBER (MILLION BOARD FEET, NET SCRIBNER SCALE)								
Puget Sound	52,904	4,723	12,759	70,386	67,974	2,040	25,113	165,513
Columbia River	71,276	15,442	35,947	122,665	155,638	25,400	13,323	317,026
SW Oregon	35,259	6,807	21,087	63,153	61,821	35,189	4,144	164,307
All districts	159,439	26,972	69,793	256,204	285,433	62,629	42,580	646,846
ALL GROWING STOCK (MILLION CUBIC FEET)								
Puget Sound	9,987	1,046	3,645	14,678	12,461	416	5,010	32,565
Columbia River	12,670	2,893	7,719	23,282	28,295	4,509	2,753	58,840
SW Oregon	5,664	1,361	4,201	11,226	12,739	5,842	767	30,574
All districts	28,321	5,300	15,565	49,186	53,495	10,767	8,531	121,979

¹ The resource data in this table and throughout this report are based on inventories completed prior to 1960. A considerable portion of the Douglas-fir subregion has been re inventoried since 1960 but the effect on the results of this report is considered to be minor. Acreage and timber-quantity definitions and standards are those of the nationwide Forest Survey.

² Large private holdings are those of owners who hold more than 50,000 acres of commercial forest land; medium, 5,000 to 50,000 acres; small, less than 5,000 acres.

A second feature of the current era, which sets it off from the one preceding, has been high and fairly continuous economic prosperity. Both the demand for wood products and the output have reached new peaks. With supplies straitened to the greatest extent in the region's history, prices of timber and its products have risen steeply. Forest land, too, has undergone price inflation as the economic prospects for timber management have brightened, and landowners, notably the large industrial owners, have striven to extend and consolidate their holdings.

The third closely related feature of the forestry trend since World War II has been the mounting interest in management of young-growth forests. Stands younger than 100 years have come to occupy half of all the commercial forest land; stands younger than 160 years, two-thirds. And if non-stocked cutovers and burns are included, the total comes to three-fourths of the commercial forest acreage (table 2). Furthermore, over 15 percent of the timber being cut now is young growth.

Table 2. — Proportion of commercial forest acreage by stand-age class in the Douglas-fir subregion and its three districts, decade of 1950's
(Percent)

Stand-age class	Puget Sound district	Columbia River district	Southwest Oregon district	All districts
Nonstocked	4.3	8.1	10.4	7.6
1-20 years	15.4	16.9	7.2	13.9
21-40 years	30.0	15.6	9.6	18.2
41-60 years	9.4	9.5	5.2	8.4
61-80 years	5.1	8.7	8.2	7.5
81-100 years	4.3	7.8	7.8	6.8
101-120 years	1.5	4.7	2.9	3.3
121-140 years	2.2	2.0	2.9	2.1
141-160 years	2.3	2.1	1.9	2.1
161-180 years	1.6	1.2	2.4	1.6
181-200 years	3.8	2.2	7.4	4.0
201 years or older	18.8	15.7	21.5	18.3
Uneven aged	1.3	5.5	12.6	6.2
All classes	100.0	100.0	100.0	100.0

SUMMARY

Nonstocked	4	8	10	7
1-100 years	64	59	38	55
101-160 years ¹	8	14	20	14
161 years or older	24	19	32	24
All classes	100	100	100	100

¹ Includes uneven-aged stands.

Little wonder, then, that recent years have seen such stress upon research in forest regeneration and in intermediate cutting and other silvicultural treatments. Increasingly, public forest owners and private owners, mostly the larger ones, are using the results of such research. With the risk of wildfire greatly reduced throughout the region (fig. 4), they have gained confidence in artificial regeneration. They are beginning to give attention, in regeneration, to seed source, to seeding techniques as well as planting, and to the use of fire as a tool. They are found here and there doing pruning and commercial thinning in stands as young as 30 or 40 years. Some of the private owners are joining those public owners that have been managing their properties in light of forest values other than timber.

And small wonder, too, in this era of adventuring into young growth, that stress has been placed on research in the economics of forestry and that the present study of trends in timber output has been undertaken.

FOREST LAND BURNED OVER ANNUALLY

PERCENT

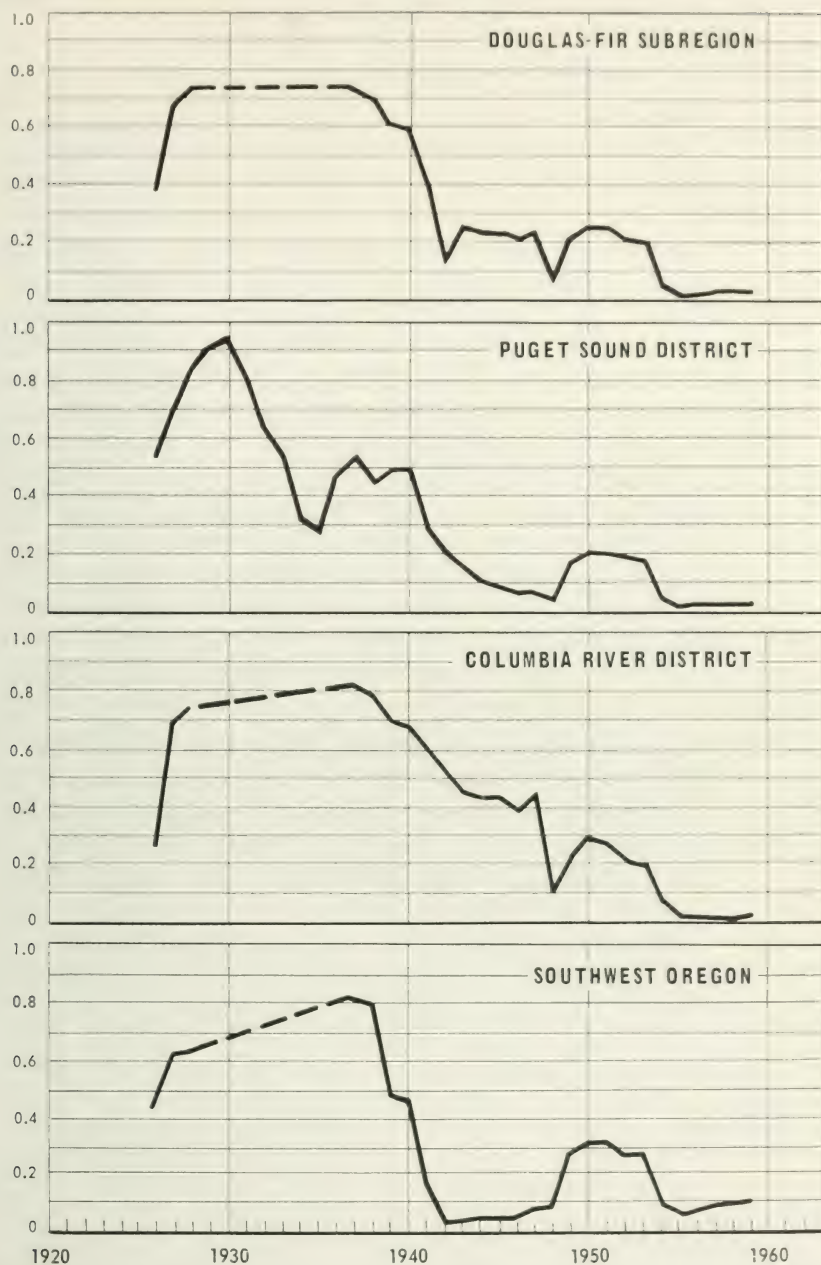


Figure 4.—Percent of commercial forest land burned over annually in the Douglas-fir subregion and its three districts—5-year moving averages, 1924-28 to 1957-61.

Chapter 2

Influences upon Timber Output

The purpose of this chapter is, first, to identify the main influences upon future timber output in the Douglas-fir subregion and, second, to derive some assumptions about the status of these influences.

Regional timber output will be the result of three sorts of influence. One is land use—the acreage and quality of land allocated to timber growing. Another is the management practices followed on allocated lands. Management may vary all the way from letting nature and local loggers take their course to pursuing an intensive regime of silvicultural outlays and investments aimed at improving the forest and increasing the value yield of timber. The third sort of influence upon output is bound up in the time element: it is the stage reached in the progression toward silvicultural goals. Ultimately, forest owners with the highest goals will produce the highest output per acre. But outputs in the meantime may be very differently related to goals. High-goal owners of young growth will be accumulating much timber increment as growing stock and postponing a large part of their output, while low-goal owners will most freely release such timber as they have for cutting. Owners of old growth will follow the dictates of their regulatory program in scheduling liquidation.

The following analysis of influences upon timber output will begin with the subject of the timber-management program, the practices followed on the forest lands of a given owner or type of owner. Next it will turn to questions of land use, and of the distribution of forest lands among the various types of owner. The third influence, the time element, will be given some attention along with the others in this chapter, but will be analyzed more pointedly in chapters 3 and 4.

Management Intensity

The thing about a timber owner's management program that most nearly determines his ultimate production is the value and efficiency of his outlays upon the forest: the intensity of his management of the forest capital. By and large, the highest gross revenues from timber will in the end be earned by those owners who make the largest investments in growing stock: the amount of it, the quality of it, and the measures for stimulating its growth, protecting it from damage, and making it available for full utilization.

Timber management that involves comparatively large per acre investments in the growth of the forest is consistent with timber conservation in the sense of foregoing immediate yields for the promise of greater yields later on. Such management will here be termed "conservative" or "intensive." For an example, consider a large-scale private forest owner in the Douglas-fir subregion, a corpor-

ation with diversified wood-manufacturing plants. Such a corporation's fixed investment in its own forests—the value of land, timber, and improvements including roads—was calculated to be \$1,736 per acre in 1959. Its additional current cost in that year for the labor (overhead and direct), equipment, and the like used in forest administration, protection, and culture was \$1.67 per acre.

In contrast to such a conservative program is the timber management which involves comparatively small per acre costs and investments in forest growth. Management of this sort, which strongly favors today's yields over those of the future and realizes relatively little of the forest's productive potential, will be termed "exploitive" or "extensive." As an illustration, take the case of a group of small farm and nonfarm forest holdings, on sites comparable to those of the corporation's forest. Where the corporation's fixed investment was \$1,736 per acre, that on the little holdings was \$790. And where the additional current annual cost on the large property was \$1.67 per acre, that on the small ones averaged 63 cents.

Although the more conservative timber management will produce the higher gross revenues in the long run, it is surely not in either the public or the individual interest for a forest owner to intensify his management indefinitely. How far he should go and probably will go depends on the costs as well as the revenues of his program. It may reasonably be supposed that an owner will want to earn the greatest excess of revenues over costs—the greatest net revenues—per unit of time.

The next revenues in question are not necessarily those from the owner's forest property alone. They are the owner's total net revenues, from all his resources, including any wood manufacturing, farming, or other investments that may be open to him. Furthermore, the aim of making the greatest net revenue is not confined to any particular year or period—it is equivalent to the aim of giving the owner's capital resources the highest current net worth, based upon all prospective revenues and costs of production.

The revenues and costs are those that measure all the prospective returns and all the prospective outlays that have value in the owner's eyes, dated as of the time or period when they will accrue or be accrued. They are not confined to material values or marketable things. They are meant to comprise all the items to which the forest owner himself attaches weight.

To earn the most net revenue in the sense here defined is an aim as reasonable to the public forest owner as to the private owner. For the public forest owner, revenue includes the public value of recreation, water, soil stability, and other forest benefits as well as timber, taking as public value that which considers the further future as well as the nearer future. Cost includes the public value of all the resources used up in forestry production. Consequently, the goal of managing public forests so as to earn the most net revenue is the goal most consistent with high national output and income in the broadest sense. It is not simply a financial, or money, goal. If it were, it would be no good for either public or pri-

vate policy. Rather, it is an economic goal, set in the wide context of intelligent resource allocation.

Some of the revenues and costs of forest production are hard to measure. They may need to be allowed for in part simply on the basis of judgment. However, as will be seen later on, the clear and basically simple idea of maximum net revenue or net worth permits of fitting judgment into a quantitative scheme, of measuring its effect, and thus of reducing its area of uncertainty.

In the subsections that follow, the major costs and revenues of timber management will be reviewed and their bearing upon the forest owner's management program and timber output will be discussed. It will be helpful to distinguish three classes of costs and revenues.

First are costs and revenues bearing on the owner's decisions concerning his growing stock, which is the principal determinant of his timber output. The decisions are mainly the length of rotation to follow and the average-per-acre amount of growing stock to carry at any time. The chief cost in question is interest on the value of the growing stock. This interest cost may be modified by any additional cost of converting from one level of growing stock to another. Taxes on property and on income may also be influential. The chief revenue item is value growth of timber, which is made up of physical growth and changes in the unit value of the growth—changes associated either with tree size and age or with other influences such as general inflation in timber values. Nontimber values associated with changes in growing stock also enter into the revenue.

The second class includes costs and revenues that bear upon the owner's decisions about silvicultural and protection measures and the degree of utilization of standing timber—items that affect output by affecting the efficiency of a given growing stock. The costs in question include those of labor, supplies, and taxes and of the maintenance and depreciation of equipment and improvements related to the technology of silviculture and forest engineering. Costs may also include interest charges upon outlays. The components of revenue are the extra timber yields attributable to the outlays, the timber price level, and, as before, nontimber values.

Third are those costs and revenues that bear on the owner's decisions about holding, acquiring, or abandoning forest land. Costs and revenues include the same items as in the first two classes, as of the period relevant to longrun investment decisions. Included also is the price of forest land for acquisitions or disposals.

Costs and revenues will be taken up in the following order: (1) interest on capital, (2) tree value in relation to age, (3) timber value trends, (4) timber value levels relative to costs of silviculture, including forest development and protection, and (5) taxes. After that, land use and forest-land ownership will be discussed.

Guiding Rate of Interest

The rate of interest at which a forest owner compounds and discounts values and makes other time comparisons will be called his guiding rate of interest. What

bearing does the guiding rate of interest have upon timber output, and what will be the magnitude of the rate for various forest owners?

Relation of guiding rate to timber output.—A hypothetical Douglas-fir forest on site III is used for illustration. Site III is medium quality, with an average index of 140 (tree total height in feet at 100 years of age). The forest is of even-aged character, being in this respect representative of most forests in the region (table 2). It is assumed for simplicity that the owner will manage the forest under a one-cut-per-rotation system and that he expects to get the yields estimated in the normal yield table (6, p. 27): the yields in board feet by the Scribner rule, considering trees 11 inches¹ and larger in diameter to a minimum 8-inch top inside bark. It is further assumed that he assigns to the yield a value of \$10 per thousand board feet; this assumption, too, is just for simplicity's sake, for in fact the choice of value has no effect upon the answer to the question now to be explored: What is the influence of the owner's guiding rate of interest upon his prospective timber output?

Columns 1 and 2 of table 3 are copied from the normal yield table. In this illustration, column 2 should be thought of as estimates of the harvest cuts obtainable from 10 alternative hypothetical forests with rotations ranging from 30 to 120 years and with 1 acre of forests representing each year of age.

¹ The 12-inch diameter class of the normal yield table, based on 2-inch classes, includes trees down to an 11.0-inch minimum.

Table 3. — Rate of return on extra growing stock as related to average annual timber yield per acre of 10 hypothetical regulated Douglas-fir forests on site III managed for one cut per rotation

Rotation (years) (1)		Yield			Growing stock			Return on extra growing stock (9)
	Cumulative (2)	Annual per acre			Cumulative (6)	Per acre		
		Total (3)	(4)	Extra (5)		Total (7)	Extra (8)	
	Board feet	Board feet	— — — — —		Dollars	— — — — —	Percent	
30	300	10	0.10	--	15	0.50	--	
40	4,500	112	1.12	1.02	255	6.38	5.88	
50	12,400	248	2.48	1.36	1,100	22.00	15.62	
60	23,800	397	3.97	1.49	2,910	48.50	26.50	
70	35,200	503	5.03	1.06	5,860	83.71	35.21	
80	45,700	571	5.71	.68	9,905	123.81	40.10	
90	55,000	611	6.11	.40	14,940	166.00	42.19	
100	62,800	628	6.28	.17	20,830	208.30	42.30	
110	69,400	631	6.31	.03	27,440	249.45	41.15	
120	75,000	625	6.25	-.06	34,660	288.83	39.83	

The yields of column 2 are anticipated yields per acre, from those acres that have reached rotation age. If the forest property is regulated, with an equal acreage devoted to each 1-year age class of timber, so that an even annual flow of stumpage may be produced, then the average annual yield per acre of the entire forest is the yield of column 2 divided by the rotation of column 1—that is, the mean annual growth per acre, as computed in column 3. The board foot yields of column 3 are converted to dollars in column 4 at the fixed rate of \$10 per thousand feet.

The yields of column 3 or 4 are alternatives just as are those of column 2. However—arising, as they do, in a regulated forest—they are long run alternatives: The forest owner cannot shift at once from one rotation to any other he may choose; he will need to do some recompartmenting of the forest and to wait out a rotation before the new program is fully in effect.

From a study of column 4, it is evident that for rotations up to 110 years, the value of the average annual yield per acre can be increased by planning a longer rotation. The amount of the increase from each 10-year lengthening, the "extra annual per acre yield," is figured in column 5. Each extra yield represents an advantage of the longer over the shorter rotation and is, therefore, a basis for comparing the alternatives. Were there no counteracting disadvantages, no costs or penalties of stretching out the rotation, the best length of rotation (the one that would fulfill the owner's aim of earning the highest net revenue) would be set by the culmination of mean annual growth at 110 years. And the timber output at which the owner should aim would be 631 board feet per acre per year. But of course there are such costs and penalties. The consequence of them is to shorten the rotation and reduce the output for the forest owner.

The principal cost or penalty in question is the necessity for carrying more growing stock in order to lengthen the rotation and raise output. Column 6 in table 3 shows the approximate value of growing stock that would be present in a regulated forest where one acre was devoted to each 1-year age class of timber up to rotation age. The simplifying assumption is made that young timber up to 25 years of age has no (merchantable) value, that all timber from 25 to 35 years has the same value as 30-year timber (300 board feet at \$10 per thousand, or \$3 per acre), that all timber from 35 to 45 years has the value of 40-year timber (\$45 per acre), and so on. Thus, 30 acres of regulated forest on a 30-year rotation would contain 5 acres of timber with merchantable value: those where ages ranged from 25 to 30 years, with a value of \$3 per acre or \$15 altogether (col. 6). And 40 acres on a 40-year rotation would contain a similar 5 acres, plus another 5 (aged 30 to 35) worth another \$15, plus 5 more (aged 35 to 40) worth \$45 X 5, or \$225. Adding these values of the 40-year forest gives the \$255 figure in column 6.

It should be explained that when a perfectly regulated forest is assumed, as in table 3 and in other similar tables and calculations in this report, this is not to imply that today's managed forests are in fact perfectly regulated or that those

of the future will be. The analyses in this report are intended to apply to real forests managed for continual yields. Table 3, stylized as it is, is meant to represent as closely as possible, on the average, not the form of these real forests, but the reasoning and conclusions applicable to them.

Let us return to the mechanics of table 3. The average value of growing stock per acre is found by dividing the column 6 values by the corresponding acreages, or rotation periods. Clearly, the value of growing stock that must be carried on the average acre (col. 7) increases with rotation and output. The amount of the increase for each 10-year lengthening of rotation, the "extra growing stock per acre," is worked out in column 8. Column 9 is simply column 5 divided by column 8, or the extra yield divided by the extra growing stock. It is a rate on the extra growing stock required to establish a 10-year longer rotation. This is not an average rate, nor an annual rate for any point of time. It is not even a periodic annual rate, for it refers to alternative completely regulated forests with uniform distribution of age classes representing each year of each rotation, rather than the same stand simply held 10 years longer. Actual rates of return for a given stand would have to be calculated by other methods, as described in standard forestry texts.

From this point, it is a simple matter to estimate, at least as a first approximation, the annual output for which the forest owner would aim. Suppose, for example, that the owner is weighing a 60-year rotation against a 50-year rotation. In the case represented by table 3, the longer rotation necessitates carrying \$26.50 more growing stock per acre (col. 8) than the shorter one. That is to say, the longer rotation requires indefinitely tying up \$26.50 per acre in standing timber—money which under the shorter rotation could be put to some other use. It could be spent for consumption, invested, or used to repay a loan.

Which alternative is the better—to invest the \$26.50 in growing stock or to use it for some other purpose? If the owner's aim is, as assumed, to earn the highest net revenue from all his resources, the answer is clear: put the \$26.50 where its net efficiency will be highest. Invested as growing stock, the \$26.50 promises to increase the annual timber yield \$1.49 (col. 5), or 5.6 percent (col. 9). If the owner can do better than this elsewhere, then presumably he will put his money elsewhere—that is, follow a rotation no longer than 50 years and produce a timber output of no more than 248 board feet per acre per year. But if the owner cannot do better than a 5.6 percent return elsewhere, then surely his aim will be to make the extra investment in growing stock, follow a rotation of at least 60 years, and produce an annual output of 397 or more board feet per acre. (In judging the rotations found in table 3, remember that the table illustrates a one-cut-per-rotation case. Under a thinning regime, as will be brought out later, indicated rotations are longer.)

Thus, the forest owner's decision about timber output in this case may be viewed as depending upon the efficiency of his alternative uses of funds—that is

to say, his alternative rate of return, or guiding rate of interest. Columns 3 and 9 of table 3 then show the owner's long run alternatives as a function of his guiding rate of interest.

Table 3 takes no account of any cost, other than interest on growing stock, of converting from one level of stock to another. Such cost may include that of engineering the converting process (compartmenting and roading the forest property and so on) and that of waiting for yields while the process is underway. If the converting is from a more to a less intensive program, the cost may be negative. The net amount of it will depend on the circumstances of the property. Because of the variability of converting cost and the likelihood that it will include negative elements offsetting the positive, the net amount of the cost is assumed, in this case and hereafter, to be negligible.

Table 3, then, illustrates the general relationship between a forest owner's longrun timber goals and his guiding rate of interest: the lower his guiding rate, the lower the rate of return he demands from his timber capital, the more such capital he is willing to carry before shifting some to other uses, and the higher his planned annual output of timber. When an owner manages his forest at a 5-percent or a 3-percent rate of interest, it means that he is trying to arrange his capital in such a way that it will increase in value at a rate never less than 5 percent or 3 percent.²

Maximizing the mean annual growth.—The decision of a forest owner to set his rotation age at the culmination of the mean annual volume or value growth may be analyzed in terms of table 3. Under the simplified assumptions of this table, such a decision means that the owner is following a guiding interest rate of 0 percent. He is ensuring only that none of his capital will earn less than nothing. That is to say, he is not shifting capital unless the capital otherwise would be destroyed. He is withholding some capital from all the alternative uses in which it has any positive value. Such a decision would be appropriate only for an owner who had no productive alternative uses for funds. If an owner has access to any outlet for investment or spending that will earn him any net revenue at all—that is, if the capital has any value to him—then he cannot economically follow so long a rotation or produce so high an output.

It is scarcely surprising to find that the forest owner will normally aim for less than the culmination of mean annual value growth. Seldom in economic life does one find a producer aiming at maximum output. The farmer does not use all the

² The approach used in table 3 is analogous to selecting the regulated forest which maximizes the present worth of the land. In this case, the present worth of land per acre is equal to the capitalized value of the average annual yield per acre, given in column 4, minus the present worth of the average growing stock per acre, given in column 7. Thus, for a guiding rate of 3 percent, the 70-year rotation in table 3 not only indicates the optimum amount of growing stock capital for the regulated forest but also maximizes the present worth of the land. Both approaches assume there is no stocking alternative for the land in the long run except a balanced age class forest producing even annual yields so long as the land is to be used for timber growing.

fertilizer that might serve to enlarge his crop. The mine owner does not hire more miners so long as they give him any increase at all in his production. A reasonable program respecting either fertilizer or miners is to add more so long as they pay their way, and likewise a reasonable timber program is to add more growing stock only so long as it promises to pay its way in terms of additional yield. From the standpoint of the individual forest owner, to maximize the mean annual value growth is to incur certain costs that fail to yield commensurate returns and thus to reduce net revenues; from the standpoint of society, it is to increase timber output at the expense of a greater value of other goods and services and thus to reduce national income.

And so it becomes apparent why a policy of maximizing the mean annual growth does not contribute, as intended, to abundance. The policy does, of course, contribute to timber abundance. But at the same time it subtracts from the national product other goods and services with a value greater than that of the timber added.

Guiding rate as reflection of nonforest revenues.—From the foregoing thoughts it is a small step to the realization that since an owner's guiding rate of interest is set by his best alternatives, whether within forestry or outside, the use of this rate in setting the timber program is consistent with the owner's aim of earning the greatest return from all his resources, forest or not.

The forest owner should plan to lengthen his forest rotation so long as the marginal return (col. 9) is above his guiding rate. Among the rotations shown in table 3, for example, the forest owner with a 4-percent guiding rate should choose a 60- rather than a 70-year rotation, earning a return of \$3.97 per acre per year. Indeed, from the standpoint of total earnings, this program does show up as the best of those listed. Rather than follow a longer rotation, such as 70 years, with its investment of \$83.71 per acre and its yearly earning of \$5.03, the owner would do better to put \$48.50 into growing stock on a 60-year rotation, invest the remaining \$35.21 at his alternative 4 percent, and garner the resulting \$1.41 in addition to \$3.97 of forest income, for a total revenue of \$5.38 altogether. Similarly, it can be shown that any rotation shorter than 60 years is, for this owner, inferior by the standard of total returns from all sources.

Looking at the matter from the regional or national view, one finds his attention directed to the manifold resources that nourish the economy. One sees that these resources are necessary to produce an output—of timber or of anything else. They are the means of production—the means of livelihood—and they are scarce. Resources tied up in any use are thereby withheld from other uses. Consequently, in order to achieve abundance—high income, wealth—a community or nation tries to put its resources into those uses that will yield the most valuable output, and to keep shifting resources from purposes that are less valuable to those that are more so. Obviously, in most cases it is in the interest of private individuals and firms thus to direct and shift their resources. For the community and nation, interest in such behavior is even more certain and clear. Assuming a fairly consistent standard

of value, the community and nation are in position to gain whenever any owner of resources, private or public, shifts them from less to more valuable uses.

Fixed interest costs in relation to timber output.—So far, this study has concerned the influence of the costs of holding timber growing stock. What about costs of holding other sorts of investment?

These other costs, unlike those of holding growing stock, fall into two distinct classes. First, there are the costs of holding investments such as roads, which may vary with timber output per acre of forest land. The variation arises through the relation of the road outlays to other forest practices: protection, thinning, and the like. This class of interest cost can be discussed most easily along with silvicultural costs.

Second, there is the cost of holding land—the interest on the land investment. This cost has a bearing on timber output through its influence upon land use, and this bearing will be brought out when the land-use topic is analyzed. Beyond the land-use effect, the interest cost of holding land has no relation to the rational program of timber management. So long as the land is used for timber growing, the investment in it is a fixed cost of production and should have no bearing upon output. Among the alternatives in table 3, a 60-year rotation and a 397-board-foot yield is the best timber program for the owner whose guiding rate of interest is 4 percent, whether he paid \$1 per acre or \$100 per acre for his land.

It is sometimes asserted that a heavy investment in land, or other large fixed carrying charge, forces a forest owner to manage his timber for higher yields than would be necessary otherwise. The point is made that only by raising the yield and thus the revenue can the owner earn enough money to defray these high charges. This assertion overlooks the other costs of timber growing just as does the philosophy of mean-growth culmination. Consider the owner, taken for illustration earlier, who plans a 60-year rotation. This owner's net revenue may represent a poor return on his investment in land. But surely he cannot better himself by increasing his rotation and his yield if the outcome will be simply a lower net revenue than before. Perhaps he can better himself eventually by getting out of the forest business. And perhaps prospective investors in forest land can appraise the anticipated return from timber in light of their guiding rates of interest and avoid paying too much for the land. Investment responses such as these may lead to changes in land use and to an adjustment of forest-land market values in line with realizable revenues. But so long as an owner's investment cost of land is fixed in reference to output, it is irrelevant to his output (and rotation) decision.

Time of reference for guiding rate.—Before it will be possible to speculate about the future guiding rates of interest of actual forest owners in the Douglas-fir subregion, it will be necessary to identify the future period or periods to which the speculation should relate.

The periods with which this study is concerned are the longrun and the transition period. The long run is that time which is far enough in the future so that

any of today's timber properties could, if it were so desired, be converted over into a forest with a normal distribution of age classes. The distribution would depend upon the chosen length of timber rotation. For the subregion in general, the long run lies at least as far in the future as the longest rotation in prospect. The transition period is the time intervening between now and then—with special emphasis, in this report, upon the next 40 years.

The dates, therefore, that are relevant to speculation concerning the rate of interest that will guide decisions about the long run are all the dates when planning for the next generation of timber may be carried out. These dates extend throughout one rotation, beginning now. The dates that apply in the case of the transition are the same, but with emphasis on the earlier dates.

Determinants of guiding rate.—What determines an owner's guiding rate of interest for timber management at any particular time? Four kinds of determinants need to be recognized.

First, the guiding rate is generally governed by the prospective rate of return from the most efficient alternative use to which the owner's resources may be put. One such use is investment or spending within the owner's business, as on forest land, timber management, or wood processing. Here, the rate that governs is the anticipated annual rate of return from this use or the owner's borrowing rate, whichever is less after allowance for risk. Another alternative use is investment outside the owner's business, as in the securities of some borrower, and here the rate that governs is the prospective yield from the securities. Still another alternative is spending for personal consumption. This type of use is most apt to be controlling for the small-scale individual owner. Judging his rate of return is a subjective process: The rate is conceived to equal the owner's rate of "time preference"—the premium he places on current consumption in preference to postponement.

Second, the guiding rate of interest is affected by various fringe benefits that may accompany the income from forestry or its alternatives. As it happens, many of these fringe benefits are attached to forestry rather than to the alternatives. For the owners who are in position to enjoy these benefits, the guiding rate of interest applicable to their forestry enterprises is lowered: Considering the fringe benefits, forest management does not need to yield so high a return as otherwise in order to compare favorably with its alternatives. Among the benefits in question is the long-term capital gains provision of the Federal income tax, which favors timber growing. Also notable is the benefit that accrues to wood manufacturers who own timberland. Their landholdings are the means for securing their timber supply and thus for securing their profits of manufacturing. To the public forest owner, fringe benefits come from timberland in the form of nontimber resources created and in the form of all resources stockpiled to insure current abundance and conserved to benefit prosperity. When the forest performs so strategic a function for the owner, he may be content with a relatively low intrinsic revenue from timber management.

Third, the owner's guiding rate of interest for forestry is influenced by his judgment of the relative risks (and uncertainties) in forestry as compared with the alternative objects of investment or spending. The risks in question are those of physical loss, as from fire, pests, and storms, and loss in value because of declining price or rising cost. The higher the risks in forestry relative to other enterprises, the higher the guiding rate of interest—that is, the more the forest enterprise has to earn in order to be comparatively attractive.

Fourth, the guiding interest rate is modified by any costs that the forest owner might need to incur in order to transfer his funds from timber into other investments. For the private owner, income taxes are the principal transfer cost. In shifting investments from the forest into other enterprises, the private owner subjects himself to one extra income taxing beyond what would be involved in the absence of the shift. The result is to lower the guiding rate of interest management, reducing the required rate of return by the percentage of the extra tax.

Changes in guiding rates over time.—To come back to the question of the date or period of reference for estimating an owner's guiding interest rate applicable to his planning for the long run and transition, it is clear from the foregoing analysis of determinants that the rate will vary and change over time. It will vary with the cycles in building activity and in business at large. It may vary seasonally, and it will vary irregularly with changes in the owner's situation and prospects. For example, the industrial owner's guiding rate will tend to move with his shifting judgment of risks and with changing prospects for other than forest investments. And the owner of the small woodland will operate at a comparatively high rate at times when his income prospects are poor or when he has heavy personal expenses to meet. All such fluctuations are rapid in comparison to the lengths of time over which timber-management planning is done and management decisions exert their influence upon the condition of the forest. Consequently, the effective guiding rate during any timber-cutting cycle or rotation is apt to be the highest rate that obtains during the period. That is to say, one may need to look at the upper range of values attained by the rate in the course of its fluctuations in order to judge what interest guide is in effect in the forest.

Beyond the short term, what changes may be expected in the guiding rate of interest—that is, in the upper range of it? Is it reasonable to anticipate a trend for the long run? Many of today's economic developments suggest a rising trend: for example, the fact of expansion in the economy and in its investment opportunity, the public policy emphasis upon rapid economic growth, the stress placed upon consumer goods in our economy, the wide choices continuously being multiplied that are offered to the consumer, the growing pressure of advertising upon the consumer.

However, in the present analysis, all reasonable weight will be attached to the contrary influences—those which will hold down the guiding rate of interest and thus favor intensive and conservative timber management. Among such influences are continuing risk reduction in the timber economy, the prospect of high

taxation of income, the opportunities for wood in general to enhance its status in our economic life, and the public efforts that will be made to bend guiding rates in the direction of the public interest.

And so it is assumed that the guiding rate applicable to each class of forest owner will show a horizontal trend in the future—that the rates effective during the time considered in this study are the upper-range rates effective today. In any case, the rates of today and the near future carry the most weight in a series, regardless of its length.

Explicit and implicit rates of forest owners.—It appears that for many forest owners the guiding rate of interest is an explicit tool of management, consciously and deliberately used for the purpose of making decisions about forest investments and spending. For example, one large manufacturer of lumber and plywood in southwest Oregon sets his timber rotations at that age which will permit the crop trees to grow at no less than a 3-percent annual rate until harvest time. This basis for the rotation and output decision is roughly the same as that developed in table 3.

Another firm in the same area, a veneer and plywood manufacturer with some 50,000 acres of forest land, aims to carry its timber investments to the point where its stumpage output, valued at market prices, will cover its cost compounded at the borrowing rate of interest, which it figures at 4 percent. This rate of return is an average rate on all outlays, in contrast to the guiding rate of interest as conceived in this study, which relates only to the last or least efficient outlays. Translated into guiding-rate terms, the firm's rate becomes somewhat less than 4 percent.

A lumber manufacturer in the Columbia River area, a family-owned concern with relatively modest holdings of forest land, uses an interest rate of 7 percent to guide its forest outlays. In setting this rate, the firm makes deliberate allowance for certain risks of which it is sharply aware, such as the risk of higher taxes and the risk of having to sell its forest property on an undependable market.

A pulp and paper company in the Puget Sound area has a vigorous land-acquisition program. This company sets its ceiling prices on tracts for prospective purchase by discounting anticipated net revenues at 3 percent as a guiding rate of interest.

Although many forest owners use guiding interest rates, no owners base all their management decisions upon an explicit rate; even if they wished to do so, imperfect knowledge of the costs and yields entailed in forest practices would prevent it. Furthermore, a great number of forest owners, particularly owners of the smaller tracts, do not use an explicit guiding rate of interest. Their decision-making process is not so orderly or so precise as to require or permit following a numerical guide.

And so, many a firm sets its forest rotation at the age when growth rates threaten to drop off below an acceptable level but does not attempt to apply this management principle precisely in cost-revenue terms. And many an owner whose finances are cramped brings his forest rotation to an end when he gets his first chance to sell his timber—or at least when the next urgent need arises for cash.

Whether the owner's basis for forest-management decisions is logically interpreted accurate data, very general judgment, or merely an impulse, every decision at least implies a guiding rate of interest. Where costs and revenues can be predicted, the rate implied can be calculated. And often the calculated implicit rate for a particular owner is found to be consistent from one decision to another.

In this study, the idea will be accepted that the rate of interest is a meaningful and realistic tool for making forest-investment decisions and for interpreting, understanding, and forecasting the decisions of forest owners. It will be recognized that guiding rates vary a great deal among owners. But it will be assumed that for each owner the rate—that is, again, the upper range of it—is essentially uniform and that there is much consistency, also, among owners similarly situated. It will be assumed that consistency on the part of an owner arises at least through the working of his general judgment, that consistency among owners is favored by their imitation of one another, and that consistency will increase as more silvicultural facts become known and as knowledge spreads. Thus, it will be maintained that owners lend themselves to a grouping or classification on the basis of the magnitude of their guiding rates, the rates within each owner group being closely similar.

Conservative large-scale corporate owners.—Among forest owners with a notably strong leaning toward intensive, or conservative, timber management are many of the big-scale, highly integrated, and diversified forest-products manufacturing corporations which provide themselves with raw material from their own large landholdings, normally well over 50,000 acres.

The typical firm in this class looks to its plant investments as its primary source of profits and would like to expect a high rate of return from these investments. From its timber resources it expects a sustaining flow of raw materials, protection from the vagaries of the open market, and thus security in its profit position, but ordinarily only a low intrinsic rate of return. To be sure, the firm has enjoyed a rapid rate of growth in the value of its forests as a result of land and timber price inflation, and it may foresee a continuance of such growth. But this fact only makes the firm more content with a low rate of value growth from within the forest.

Its raw material interests lead the firm to organize its landholdings for conservative management under intensive professional supervision, to try a wide range of silvicultural programs, to practice close utilization of wood in the forest as well as in the mill, and generally to take the lead in the forestry developments that characterize the current era.

The firm's risks of timber management appear to be low. With extensive landholdings, risks of physical loss are well spread. Risks of value loss are commonly judged to be negligible: specific forest products may lose favor in consumer's eyes as time goes on, but the value of wood in general as raw material is regarded as secure. Its corporate form enables the firm to take a long and continuing view of its business and to plan ahead to distant horizons that are undisturbed by considerations of the life span of today's decision makers.

The guiding rate of interest to be taken here as representing the timber management of this class of firm is 3 percent.

Federal Government as a conservative owner.—Another forest owner generally believed to function at a low guiding rate of interest is the Federal Government. Federal planners weighing prospective investments in resource development have often used interest rates of 2-1/2 or 2 percent. Sometimes it is held that the rate to use is the carrying charge on the national debt, which now runs about 3 percent. Some studies suggest a rate as high as 5 or 6 percent (4). In any case the rate sought is, like that for private concerns, an alternative rate of return adjusted for fringe benefits, risks, and transfer costs.

The Federal Government's timber investments are, in the last analysis, financed by taxation. That is to say, the Government's alternatives are (1) to take timber income, as through liquidation, or otherwise refrain from investment and (2) to raise the funds by taxation. Under conditions of full employment, the appropriate guiding rate of interest to be used might be set at the estimated average rate of return that private individuals and firms may expect to earn on their resources and thus contribute to the national product were they not to transfer the resources to the Government in the form of taxes. The implication is that the Government must foresee earning at least as high a rate as this in order to justify its investment and its attendant taxing.

However, a number of considerations are arguments for holding the Federal rate for timber-growing investments below such a level as 5 or 6 percent. One is the existence of fringe benefits of Federal timber management: benefits from nontimber values and from pursuance of the national conservation policy to alter resource use in favor of future generations. Among fringe benefits may also be included that of helping to secure the national raw-material supply, a benefit to society analogous to what the integrated private firm enjoys, and similarly serving to lower the guiding rate of interest. Another consideration is the longrun obligation of the Government to offer the Federal forests as examples of successful conservative practice. It would be scarcely rational for the Government, with its paramount long-term interests and its responsibilities for the wood supply, to manage its own holdings generally at any higher a guiding rate than that appropriate for the group of most conservative private owners.

The guiding rate of interest chosen here to represent the forest decisions of the Federal Government is 3 percent.

It is well to emphasize what it means to choose an interest rate, such as 3 percent, to signify the forest-management policy of the Federal Government. Most notably, it means that one is assuming an economic aim for the Federal forests: the aim of making—not money primarily—but net revenue in the form of all the materials and services of the forest that have public value, over the whole span of time for which the public is concerned.

Thus, in choosing an interest rate, one simply accepts the economic aim of continually shifting capital and other scarce resources from less into

more valuable uses: the aim of substituting, wherever possible, a revenue for a cost.

Of course there is always the question whether, under the economic approach, revenue and cost are acceptably measured.

Consider, for example, the important matter of forest rotation length. Does not the economic approach belittle the intangible values of scenery, water, wildlife, and so on? And is not the economic rotation, therefore, too short? Again, is not forest management peculiar in respect to the long period of production it involves? and does this not imply that exceptionally long-range planning is necessary in forestry? Does it not also imply the need for exceptionally high allowances for emergencies—that is, extra large ultimate outputs, such as one may get through the use of extra long rotations? Is timber, perhaps, peculiar among resources in that the public may quite properly subsidize the holding of it at the apparent expense of other resources?

There are, indeed, imponderables and other special elements in public forestry which must be accounted for in any acceptable management procedure. Those elements which give rise to extraordinary values for older or larger timber—for instance, scenic values—militate toward longer rotations. Conversely, other elements may favor shorter rotations or be quite neutral in respect to rotation length. In general, the goal to be pursued is to create the greatest possible sum total of net values on the public forests. The economic rotation as developed in this report is an idea consistent with such a goal. The difficulty, admittedly, is choosing the right values to use in calculating the rotation. The choice must rest partly on judgment—such as the judgment of a 3-percent guiding rate of interest for Federal forestry. At least the judgment can be applied—and is believed to be applied here—with explicit recognition of the issues involved.

Exploitive forest owners.—It will be helpful to turn from the forest owners with most conservative leanings to their antitheses, the owners with most exploitive leanings. In this contrasting class are to be found some private forest owners of nearly every size group and type. However, the sort of owner that comes closest to typifying the class is the small-scale individual or family owner whose principal interests are other than the forest and whose principal income likewise is from other sources and is meager by the standards accepted in the community.

Such an owner is apt to be poorly acquainted with the potentialities of timber management. He is poorly equipped, in view of his economic insecurity, to take advantage of such knowledge as he may come by. His planning outlook as well as his tenure is likely to be short. His timber-management practices are the result not so much of his own decision as of the convenience and importunity of local loggers, who keep the forest trimmed back to the extent that its merchantability permits.

The guiding rate of interest of such a forest owner is influenced by the fact that consumption alternatives of high priority commonly govern the owner's aware-

ness of timber-management risks, associated with protection, utilization, marketing, and other phases of the adventure. The consequence of influences of this sort is a high guiding rate of interest: 10 percent, 20 percent, or often much more. A rate may be so high that it greatly exceeds the top rate of value growth of which the forest is capable. Such a rate suggests merely that the owner who has no other use for forest land will sell timber from it as often as there is timber to sell and someone willing to buy. Thus, beyond a point, the magnitude of the rate can have little influence upon timber output, which will already have fallen approximately to the minimum consistent with successful tree regeneration.

Here, to represent the exploitive class of forest owners, a guiding rate of interest is chosen which is about as high a rate as can generally be given a silvicultural interpretation. The rate chosen is 12 percent.

Owners with intermediate guiding rates.—The range between the class of conservative owners with a guiding rate of 3 percent and the class of exploitive owners assigned a 12-percent rate is here looked upon as a single intermediate class. For this class, the mean rate of 6 percent is assumed to be the guiding rate of interest.

In this intermediate class fall some owners of large forest holdings and also many owners of small tracts who have special motivation for timber growing. It is assumed that the bulk of this class is made up of State and local government and the family-owned wood-manufacturing concern with a middle-size forest holding. These owners are distinguished from the most conservative class in being confronted with higher risks of timber production and in having a more restricted horizon in their planning for the future.

Specific assumptions about the future acreage of commercial forest land in each of the foregoing three classes of ownership will be developed in a later part of this chapter, where the subject of ownership trends is analyzed, and in chapter 3.

Guiding rate as a comprehensive value index.—Let us summarize the point of view taken in this study with respect to the guiding rate of interest. The rate is regarded and employed as an index of all those considerations that may affect a forest owner's valuation of capital and by this means enter his decisions about using capital: the amount of it, the purposes to which it will be allocated, and the timing of its use. Such decisions are, by a wide margin, the most influential in forestry; in great measure, they determine the output of forest materials and services. Consequently, it is a large role that is here assigned to the guiding rate of interest.

Although some forest owners consciously use an interest rate to guide their judgements, many—and indeed, the great majority—do not. However, whenever a decision is made about forest capital, whatever the basis for the decision, a rate of interest is implied and can be derived. The use, then, of a guiding rate in the present analysis merely assumes two things. First, it assumes that the forest owner is consistent, in time and among the objects of investment and spending, in respect to the value he attaches to capital. Second, it assumes that this value, this implicit

guiding rate of interest, can be closely estimated for a class of owners and that it is so estimated in this instance.

The resulting rate of interest is intended to reflect the owner's ability and desire to use forest capital, not only to make wood but also to furnish recreational and watershed services and other forest tangibles and intangibles now and in the future.

Tree Value in Relation to Age

The source of forest revenues, so far as wood is concerned, is the value growth of timber. Table 3 illustrates how value growth defrays the cost of holding growing stock and makes it profitable to postpone the harvest for a while, meantime augmenting the ultimate output. It will be remembered that value growth in table 3 derives only from volume growth—a fixed timber value of \$10 per thousand board feet is assumed.

However, a forest's value growth may arise from more than just its production of volume growth as in table 3. Value growth may come also from (1) lower conversion cost per unit volume with advancing size and age, (2) the prospect of forest reestablishment costs following the harvest, (3) improvements in timber quality (higher product value per unit of timber volume), and (4) inflation of timber values relative to the general level of values in the economy. The first three of these influences will be taken up at this point; the fourth, in a later section.

Nature of effect of conversion cost differentials and reestablishment costs on timber yields.—Suppose that, as a result of a prospective lowering of conversion cost with age, the anticipated value of the Douglas-fir stand of table 3 is not constant at \$10 per thousand board feet, as assumed there, but increases from \$10 at 30 years of age at a rate of 1/2 percent per year:

<u>Stand age</u> (in years)	<u>Value per M board feet</u> (in dollars)
30	10.00
40	10.51
50	11.05
60	11.61
70	12.21
80	12.83
90	13.49
100	14.18
110	14.90
120	15.67

In this event, the value growth—expected percentage return of column 9—is increased. Table 4 displays the alternatives with which the forest owner is now confronted and compares them with the table 3 alternatives. It suggests that, in the range of interest rates from 12 to 3 percent, rotations in this particular case will tend to be lengthened by about 1 to 4 years and output increased accordingly.

Thus, the influence of lower conversion cost per unit of volume with advancing size and age, though possibly small, is perceptible and significant.

Table 4. — Rate of return on extra growing stock as related to average annual timber yield per acre of 10 hypothetical regulated Douglas-fir forests on site III managed for one cut per rotation—assuming that timber value per board foot increases 1/2 percent per year of age

Rotation (years)	Yield				Growing stock			Return on extra growing stock	Return shown in column 9 of table 3
	Cumulative	Annual per acre		Cumulative	Per acre				
		Total	Extra		Total	Extra			
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
	<u>Board feet</u>	<u>Board feet</u>	— — — — —		<u>Dollars</u>	— — — — —		— —	<u>Percent</u> — —
30	300	10	0.10	--	15	0.50	--	--	--
40	4,500	112	1.18	1.08	266	6.66	6.16	17.5	17.3
50	12,400	248	2.74	1.56	1,188	23.76	17.10	9.1	8.7
60	23,800	397	4.61	1.87	3,255	54.25	30.49	6.1	5.6
70	35,200	503	6.14	1.53	6,785	96.93	42.68	3.6	3.0
80	45,700	571	7.33	1.19	11,866	148.32	51.39	2.3	1.7
90	55,000	611	8.24	.91	18,507	205.64	57.32	1.6	.9
100	62,800	628	8.91	.67	26,670	266.70	61.06	1.1	.4
110	69,400	631	9.40	.49	36,292	329.93	63.23	.8	.1
120	75,000	625	9.79	.39	47,339	394.49	64.56	.6	-.2

As for prospective forest reestablishment costs, such as of site preparation and planting or seeding, they tend to influence the rational forest owner to lengthen his rotation (and raise his output) in order to reduce them by postponement. Their effect upon the percentage return from timber growing may be thought of as exerted through the extra annual yield per acre. For example, if the owner anticipates a reestablishment cost of \$30 per acre at the end of the rotation, he can reduce this reestablishment cost per average acre of regulated forest by lengthening the rotation, as follows:

<u>Rotation</u> (in years)	<u>Reestablishment cost</u> (in dollars) <u>per average acre</u> <u>of regulated forest</u>
30	1.00
40	.75
50	.60
60	.50
70	.43
80	.38
90	.33
100	.30
110	.27
120	.25

When these reestablishment costs are deducted from the total annual per acre yields of column 4 in table 4, the result is as shown in table 5. Percentage returns are raised above those in table 4, and indicated rotations are lengthened—about a year in this case. Again the effect may be small, but it is significant.

What predictions are being made by thoughtful forest owners concerning timber value differentials, and what assumptions are reasonable to propose for the future? The issues regarding changes in unit value of wood with forest age are the sharpest and potentially the most influential.

Table 5. — Rate of return on extra growing stock as related to average annual timber yield per acre of 10 hypothetical regulated Douglas-fir forests on site III managed for one cut per rotation—assuming that timber value per board foot increases 1/2 percent per year of age and that it costs \$30 per acre to reestablish a stand after cutting.

Rotation (years)	Yield				Growing stock			Return on extra growing stock	Return shown in column 9 of table 4
	Cumulative	Annual per acre			Cumulative	Per acre			
		Total	Extra			Total	Extra		
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
	<u>Board feet</u>	<u>Board feet</u>	— — — — —	— — — — —	<u>Dollars</u>	— — — — —	— — — — —	— — — — —	<u>Percent</u> — —
30	300	10	-0.90	--	15	0.50	--	--	--
40	4,500	112	.43	1.33	266	6.66	6.16	21.6	17.5
50	12,400	248	2.14	1.71	1,188	23.76	17.10	10.0	9.1
60	23,800	397	4.11	1.97	3,255	54.25	30.49	6.5	6.1
70	35,200	503	5.71	1.60	6,785	96.93	42.68	3.7	3.6
80	45,700	571	6.95	1.24	11,866	148.32	51.39	2.4	2.3
90	55,000	611	7.91	.96	18,507	205.64	57.32	1.7	1.6
100	62,800	628	8.61	.70	26,670	266.70	61.06	1.1	1.1
110	69,400	631	9.13	.52	36,292	329.93	63.23	.8	.8
120	75,000	625	9.54	.41	47,339	394.49	64.56	.6	.6

Assumptions about conversion-cost differentials and reestablishment cost.—

As regards increases in unit value of timber resulting from decreases in conversion cost with advancing age and size, past studies show great differentials, but suggest also that the differentials are shrinking in Douglas-fir country and may be expected to become still smaller as time goes on. Brandstorm's work published in 1933 (1, table 46, p. 76), covering the costs of logging and transportation by methods adapted primarily to old growth, shows especially large differentials in the tree-size range from 14 to 24 inches or so, d.b.h. Interpreted for site III timber with \$10 stumpage value at 50 years of age, Brandstorm's differentials amount to an increase in value per thousand feet of close to 1 percent annually over the remainder of a rotation. More recent studies (5, 10, 11) point to lower value dif-

ferentials, on account of logging and transportation costs, down to 1/2 percent or a little less per year of age.

If cost studies were extended through the log-conversion plant, so as to reflect stumpage-value differentials in terms meaningful to the integrated forest owner, these differentials would be found somewhat larger than the ones just cited.

On the other hand, all available data and experience on conversion costs relate to an era which differs markedly from the future period with which this study is concerned in that the conversion industry was in continuous process of adapting itself to smaller raw material and was always under some technological disadvantage in handling the new average sizes of the day. It is reasonable to suppose that, in a stabilized young-growth economy, converters will match their methods to their materials in such fashion as to minimize both the absolute and the relative disadvantages of handling small-diameter and short-length wood. Some clue to what the industry may expect is, perhaps, to be found in past cost data for the tree sizes to which converters were well adapted at the time. Thus, Brandstrom's cost differentials for trees in the 30- to 40-inch range, if applied in the size range considered earlier (14 to 24 inches), would represent a per thousand value differential of less than 1/4 percent per year on \$10 stumpage in contrast with the 1-percent contained in the Brandstrom data for 14- to 24-inch trees. On stumpage of higher value, the differential would be less than 1/4 percent, but, on the other hand, it would tend to be pushed up if milling costs were accounted for.

It is assumed in this study that the effects of conversion cost differentials and of reestablishment costs upon the timber-management program are suitably allowed for by adding 1 percent altogether to the value growth percentage of the forest—that is, to the figures such as in column 9 of table 3, based on constant value per unit of measure. This method of making the allowance is admittedly rough. Strictly, the proper allowance will vary with such factors as forest site quality, the owner's guiding rate of interest, the unit of measure to be used, and the costs of conversion and reestablishment in relation to other costs and to revenues. However, the errors are small in comparison to the allowance itself, and their weight in the end result is believed to be negligible.

Assumptions about quality differentials: saw log objective.—As regards increases in unit value of timber resulting from improvement in quality of wood (end-product value) with advancing tree age and size, some wide differences in judgment are to be found among persons who have studied the question. On the one hand are those who believe that logs capable of yielding the larger cuttings with fewer knots will always command a great premium, and that the ideal log of the future, though not conceivably matching yesterday's deep-clear peeler, yet is its young-growth counterpart. For those whose thoughts run in such a vein, the goal of timber management is a relatively long rotation. For them, the ideal management program would include artificial pruning, since Douglas-fir makes such small gains by natural pruning, even in rotations of 100 to 120 years.

At the other extreme are those whose philosophy for the future is that wood is wood and quality, however our standards concerning it may develop over the years, will not be grown into the product but will be manufactured into it mechanically or chemically. This, of course, is short-rotation thinking that provides little if any place for pruning in the silvicultural program. It is a point of view that one expects to find, and does find, in the pulp and paper industry. But it is common also in the mechanical processing industries, conspicuously in veneer and plywood. Here it may seem to be out of place until one reflects that this industry more than any other has been forced to adapt itself to its raw material and has gained confidence in its continuing ability to adapt.

So wide is the range of judgment about future timber quality differentials that two alternative assumptions are made in this study. These assumptions, lying between the extremes outlined above but situated near each end of the range, are termed a saw log objective and a wood objective. The two assumptions can be viewed as the basis for any mixed, intermediate assumption.

The saw log objective assumption is that longrun future values per board foot of timber will not vary with tree age or size on account of end-product quality: The assumption is that a board foot of lumber is a board foot of lumber, so long as it is made from trees 11 inches and larger in diameter utilized to a minimum 8-inch top inside bark and so long as the amount of it is estimated by the Scribner log rule. In other words, the average value per board foot of products made from 30-year-old-trees is assumed to be the same as that from 120-year-old trees. To apply this assumption in this analysis, constant value per board foot is assigned to the Scribner log rule estimate of board feet. This actually results in a slight allowance for increasing value of lumber per board foot lumber tally. For a constant price of \$10 per thousand board feet, Scribner log scale, the corresponding stumpage price per thousand board feet lumber tally ranges from \$7.50 for 30-year-old timber to \$8.97 for 120-year timber. Since International 1/4-inch log rule closely approximates lumber tally throughout a wide range of tree sizes, it can be used as a best estimate of lumber recovery. The slight increase, then, is illustrated in the following tabulation of normal Douglas-fir yields on site III by comparing board-foot International 1/4-inch for trees 11 inches and larger in diameter to an 8-inch top with board foot Scribner under the same utilization standards (6, pp. 27, 66) for the same stand ages:

Stand age (years)	Total yield, International 1/4-inch (Board feet)	Total yield, Scribner (Board feet)	Price per M, International 1/4-inch,
			if \$10 per M for Scribner (Dollars)
30	400	300	7.50
40	5,400	4,500	8.33
50	14,600	12,400	8.44
60	27,800	23,800	8.55
70	40,600	35,200	8.66
80	52,200	45,700	8.75
90	62,300	55,000	8.83
100	70,600	62,800	8.90
110	77,600	69,400	8.94
120	83,500	75,000	8.97

Although this is only a slight allowance for increase in end-product unit value with age, it is an adequate allowance when compared with published results. McBride (7, 8) found relatively small influence of log diameter on the value per board foot lumber tally of lumber recovered from 8-inch and larger logs. Translated into trees, this influence is still smaller. Matson (5) stated that, without pruning, no clear grades of lumber can be expected from young-growth Douglas-fir up to 100 years of age.

This assumption of constant end-product quality irrespective of tree age and size is believed to place as much emphasis upon conservative management as is defensible in view of the fact that much of yesterday's and today's premium on log size has stemmed merely from the existence of obsolescent but undepreciated plant capacity for converting vanishing categories of timber. The day will come when all such categories have vanished and those that are left can be counted upon to reproduce themselves.

The saw log objective assumption implies that mechanical wood-conversion industry will prove reasonably flexible and fairly adaptable to raw material supplies and will continue in the long run to be a major user of timber in the Douglas-fir subregion. The assumption is substantiated by the fact that the subregion is outstanding among forest areas of the United States in the long life, fast growth, and long-sustained growth of its principal trees. Surely Douglas-fir and its associates will be a prime source of the larger softwood logs required by the Nation, particularly while a great share of its products are various forms of solid wood.

Assumptions about quality differentials: wood objective.—However, there is still ample room for the other assumption made in this study. The wood objective assumption is that longrun future values per cubic foot of timber will not vary with tree age or size on account of end product quality: Wood is wood, measured in cubic feet of sound, straight sections of trees 5 inches and larger d.b.h. to a

4-inch top—i.e., by the Forest Survey standard (6, p. 22). The presumption is that, in the sort of forest economy here implied, wood quality will be related principally to attributes of the tree other than size and age and so will exert little effect upon timber rotations and yields.

The wood objective is one that might well apply if chemical conversion came to dominate forest industry. At the least, the wood objective assumes a high degree of adaptation to raw material on the industry's part. It assumes that the adapting will be paced by the users of wood as fiber: that their technological advantages over the sawyers and slicers of wood will continue in force. It supposes that consumers, too, will adapt themselves to the raw material resource that is easiest for the industry to create and convert.

Timber Value Trends

A rising trend in the price of most timber products and of stumpage has for a great many years been a prominent feature of the forest economy in the Douglas-fir country. This trend and the expectation that it would continue have undoubtedly had a large influence upon forestry developments. Their influence can be traced in speculation in forest property during the early era and in the subsequent gradual intensifying of protection, utilization, and silvicultural programs of many forest owners. Over the period from 1910 to 1960, the trend in Douglas-fir stumpage prices relative to the general price level (13, table 4, p. 37; 14, table 1, p. 51) was upward at an average annual rate of about 4 percent. These relative stumpage prices are plotted year by year in figure 5. The data are prices paid for National Forest timber sold. This timber declined somewhat in quality and accessibility over the period. For timber of a given description, the upward price trend may well have been steeper.

DOUGLAS-FIR STUMPAGE PRICES

PRICE PER M BOARD FEET, SCRIBNER RULE
1957-59 DOLLARS

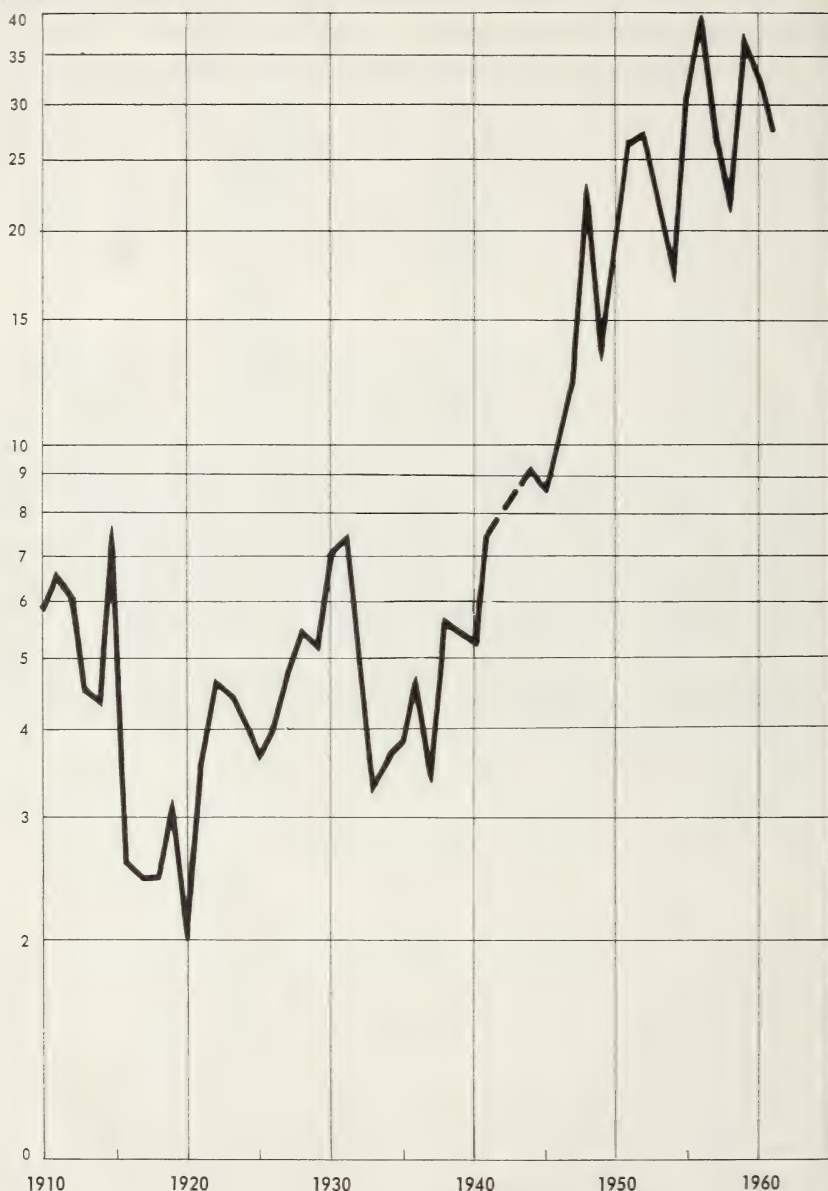


Figure 5.—Douglas-fir stumpage prices in the Douglas-fir subregion, 1910-61, in 1957-59 dollars (adjusted by Bureau of Labor Statistics wholesale price index of all commodities).

A prospective upward trend in timber values influences forest management through the value growth that it represents and through the absolute level to which it promises to push timber value. The first of these influences will be taken up here. The second will be studied immediately afterward under the heading "Timber Value and Management Cost Levels."

Influence of a trend.—The effect of conversion cost differentials upon rotation and yield was illustrated in table 4. The effect of a general trend in value over time is similar, though for a given percentage differential the effect on rotation length is smaller because an upward time trend increases growing-stock investments as well as value growth for each rotation alternative. Thus, the rise in percentage return is dampened, so that the upward pressure upon rotation and yield also is dampened.

Nevertheless, the expectation of a 4-percent or higher value trend can be counted on to wield great influence upon the actions of the forest owner. It has an effect similar to the application of fertilizer to a young-growth forest. But the fertilizer in this case is free—a gift from consumers—and it increases tree increment without the necessity for widening the annual rings. To old-growth timber investments, the value trend lends new vigor. Old-growth stands, even those that are static in respect to net wood volume, become a perfectly desirable investment for the conservative owner when a 4-percent or greater value trend is in prospect. Indeed, as experience shows, he may be glad to hold such stands indefinitely if property taxes allow and if he is not pressed for raw material.

Assumptions about the trend.—The rising stumpage price trends of the past are the result of influences which, though still active today, nevertheless are already in a process of change which may well lead to their disappearance—and, what is more to the point, are already impressing forest owners with their impermanence.

The demand for stumpage presumably is derived from the demands for lumber, plywood, paper, and other forest products. These latter demands have long been rising with national population and income and with the persistence of consumer preferences for wood. Rising demand has been evidenced, in the case of wood-pulp products, by a rising national consumption trend, per capita as well as total. In the case of lumber, it has been witnessed by sustained total consumption in the face of steeply mounting prices.

Growing demands for stumpage have not been met by a like response in supplies. In the Douglas-fir subregion, stumpage supplies receded with the old-growth timber. From the earliest times, this receding, together with the threat of scarcity and the organization of forest properties under deliberately conservative cutting programs—that is, timber management itself—has served to hold down the supply for cutting. Meanwhile, young-growth production did not fill the gap. The major, mechanical conversion segment of wood users, and especially the lumber industry, lagged in its adaptation to raw material. And the supply of young growth was not yet big enough (nor that of old growth yet small enough) to encourage

widespread adaptation. Among the regions of the United States, only the South was seeing a strong resurgence of industry based on young-growth timber.

Thus, during most of its life the wood-using industry of the Douglas-fir subregion has been in process of transition. During industrial transition, when new technology and new firms are coming in to replace the old, basic exhaustible resources that were of high grade under the old regime are almost bound to assume greatly inflated values as the hard-pressed lagging element of the industry fights over them for survival. Old-growth timber qualifies as an exhaustible resource. And during transition the process of substitution draws all timber into the scheme of rising values. Over the past couple of decades, while the plywood industry was increasing its take to about 30 percent of the entire saw log output of the subregion, Douglas-fir log prices were rising more than 3 percent per year relative to all commodities.

The rising trend in stumpage values, compared with the general average of values in the economy, seems likely to continue for some time in the United States, and the Douglas-fir country may be expected to share in this experience. Some rise will take place so long as demands keep edging ahead of supplies. However, for the long run, the likeliest assumption, not to say the most cautious one, is that forest owners will no longer foresee such a trend clearly enough for it to influence their management decisions—that is, they will come to expect stable values. They will see a fair abundance of young-growth timber coming on. They will understand, more fully than today, the Nation's forest-supply potentialities. Thus, much of the speculative element in timber values will be removed. Furthermore, forest owners will expect the consumers of wood products to adapt themselves to the timber supply by changing their scale of preferences and turning to products made from cheaper substitutes.

Today, many forest owners in the Douglas-fir subregion are already viewing future stumpage values with caution. In their long-range management planning, even those who take account of expected continuing general inflation are reluctant to consider a rising trend in the relative price of stumpage. The assumption made in this study is that any outlook for rising relative prices of stumpage will in future exert continuously less influence upon timber management. Where, in the analysis, specific assumptions regarding the price level are required, the levels used are as follows except where stated otherwise: for material of saw-timber size (trees 11 inches or larger, d.b.h., to a minimum 8-inch top) an average of \$40 per thousand board feet, Scribner rule, in the terms of figure 5; for smaller material, positive values ranging downward to nominal amounts per cubic foot in 5-inch trees to a 4-inch top in stands having the least favorable composition, volume, and location.

The longrun output of timber that is projected later in chapter 3 will be down if a price less than \$40 is assumed in this study.

Timber Value and Management Cost Levels

Apart from trends, the level of timber values that forest owners and potential owners foresee, in relation to the anticipated costs of growing timber, will have an effect on management programs and timber output. Some of the major management items through which the revenue-cost prospect will influence output are as follows:

1. Land use. Other things being equal, the higher the prospective unit value of timber is in comparison with costs of production, the more forest land will be given over to timber growing, and the more nonforest land will be converted to timber use.

2. Forest administration and protection. The higher the prospective unit value of timber is, the more the forest owner and the community will be inclined to lay out for transportation facilities and other forest improvements, fire control, professional services, and the like.

3. Forest regeneration. The higher he expects the unit value of timber to be, the more the forest owner will be willing to pay for insuring prompt and successful regeneration of superior trees.

4. Forest site improvement. The higher the anticipated unit value of timber is, the more practicable it may become to apply fertilizer to forest lands and to carry out other site-improvement measures.

5. Timber-stand improvement. The higher the prospective unit value of timber is, the greater the incentives are to carry out any weeding, thinning, or other stand-improvement measure promising a deferred return in the form of extra yield.

6. Timber utilization. The higher the current unit value of timber and its products are, the further the forest owner and timber converter will extend their utilization. They will extend utilization to new tracts and within the tract to new trees and parts of trees. They will tend to enlarge the practice of intermediate cutting and to shorten the cutting cycle. And they will be inclined to convert a larger proportion of all harvested material into end products.

Respecting all six of the foregoing management items, higher timber values (relative to costs) tend to exert their influence upon practice in a progression from the most favorable toward the least favorable situations: from good sites into poorer, from easy terrain into more difficult, from the most conservative owners toward the more exploitive, and so on. Through the first five items, wider prospective price-cost margins have the effect of intensifying timber management on all forest holdings. However, the relation of the sixth item, utilization, to management intensity may be somewhat different, depending upon the forest owner's guiding rate of interest. For conservative owners, with a low guiding rate, high timber values may work through the utilization factor to intensify management. But for exploitive owners, high values may simply further the opportunity for and the practice of exploitation.

Of the six management items, the first (land use) and part of the second (roads) will be discussed later under those headings. The rest of the items will be taken up now.

Forest administration and protection.—The key to administration and protection on any forest is access. This, in today's terms, means roads. In terms of the long run, it means the transportation devices of the time, whatever that may be: air or ground systems or some combination. The technology of forest access may be expected to develop in accordance with the opportunities to reduce cost. The greatest reductions in transportation cost may be looked for in outlying, rugged areas. Technological developments may well have the effect of reducing transportation cost differentials between today's easy and difficult areas—that is, of putting all areas more nearly on a par when it comes to access. Any replacement of ground by air systems will surely have such a tendency.

In recent years, the intensified forestry programs of conservative private owners in the Douglas-fir subregion have been paced by road building. These owners have paid for their roads out of the proceeds from relogging of cutovers, prelogging and harvest cutting of mature timber, and the anticipation of thinnings and final cuts from other areas. And the roads have been generally justified, too, by their role in safeguarding timber values against damage and in permitting the salvage of damaged timber. Road development has been accompanied by great intensification of forest fire control and other protection measures. And the staff of professional foresters and other forest workers has been enlarged in keeping with greater forestry accessibility and the new opportunities for management thus created. Today's price-cost ratios and price-cost anticipations have been ample to stimulate these actions by conservative private owners.

More exploitive private owners, with their higher rates of discount, are less strongly motivated to develop their forest administration and protection where yields are far in the future. On the other hand, their tracts are generally more accessible to begin with because of size and location. And their interest in immediate returns has encouraged them to build forest roads wherever necessary for capturing current values.

Public forest owners hold most of today's highly inaccessible forest lands. Some of these lands present excessive difficulties for administration and protection in light of current technology. However, even at present prices and costs, such is the public interest in forest values besides timber and in developing the public forests as examples of conservative management that most of the difficult areas are due for intensive development as soon as appropriations or cutting programs or the solving of right-of-way problems permit. And in the long run, it seems fair to assume that all areas will be thus developed, even in the absence of any further price-cost incentives.

For the long run, it is assumed that transportation will be such as to permit ready and relatively equal access to all acres of commercial forest. It is assumed that public and private forest protection efforts, coupled with excellent opportunities

for salvage, will reduce timber losses to a negligible level. And it is assumed that the timber management appropriate to each class of forest owner will be supported by technical foresters employed by the owner or available to him from public sources.

Forest regeneration.—So far as the value of output in relation to cost is concerned, management decisions respecting forest regeneration center around the choice between natural and artificial regeneration. The latter method has primarily three points of advantage: first, it may reduce or eliminate delay in starting a new crop; second, it may insure establishing just the species and strains of trees that are wanted; third, it may insure the best spacing of stems without the necessity for very early treatment of the stand. The rational forest owner can be expected to use artificial regeneration wherever he can foresee that these advantages will outweigh the extra costs of planting or seeding.

For example, considering the costs of artificial regeneration and the costs of treating young natural stands, suppose that artificial regeneration requires an outlay \$10 (1947-49 basis) greater per acre than that required by natural regeneration. But suppose that, as a countervailing influence, the yields from natural stands under a regime of intermediate cutting fall 10 percent short of plantation yields.

Then take the case of the conservative owner of average site (index 140) Douglas-fir. As will be developed in chapter 3, this owner's best program is an 80-year rotation with a prospective annual per acre yield of about 580 board feet, Scribner rule. If artificial regeneration involves an extra cost of \$10 per acre, its extra cost per acre per year under an 80-year rotation is 12.5 cents. At the same time, its prospective 10-percent saving of yield is 58 board feet per acre per year. At \$40 per thousand, this saving amounts to \$2.32. Even if the entire saving were postponed for a full rotation, which is an overly conservative supposition, the current value of it would be \$2.32 divided by 1.03^{80} or 21.8 cents per acre per year—more than enough to justify the 12.5-cent cost.

Similar figuring on the basis of the same assumptions leads to the conclusion that the conservative owner has even clearer justification for artificially regenerating good site (index 170) Douglas-fir land with its higher yield, shorter rotation, and greater risk of hardwood invasion. On poor sites (index 110), despite lower yield and a longer rotation, artificial regeneration still has the advantage so long as the probable delay in getting natural reproduction is as much as 3 or 4 years. On upper slopes, where even longer rotations are indicated, the great advantage of assuring stands of red or noble fir and white pine in preference to mountain hemlock again gives the edge to artificial regeneration.

The intermediate forest owner with a 6-percent guiding rate of interest is found occupying a marginal position between natural and artificial regeneration when the foregoing assumptions are used. But when it is considered that extra yields of artificial stands may well commence with the earliest commercial thinnings and that the yield advantage of such stands over natural stands will probably be enlarged by innovations in the area of forest genetics, the intermediate forest

owner, too, becomes a candidate for the practice of planting or seeding so long as there are serious risks of delay of more than a very few years in getting natural regeneration.

It therefore appears that the economic climate of the future will be highly conducive to prompt forest regeneration. Because of the preponderant economic advantage on most lands, laws requiring prompt regeneration will probably remain in force and will bring about conformity in the doubtful cases, the poorest sites and the holdings of exploitive owners.

However, at such levels of stumpage value as have been analyzed here, the exploitive owner with a 12-percent rate of discount can be expected to have difficulty justifying forest seeding or planting so long as alternatives are open to him for conforming with regeneration requirements of the State forest conservation laws. Artificial regeneration may recommend itself to him on the best sites and in cases where a plantation has special values in his eyes or where his establishment costs are exceptionally low. But typically he will rely on natural regeneration. He will be glad to sacrifice some prospective timber yields in order to escape the immediate cost of getting regeneration.

In figure 6, the possible response of the exploitive forest owner to stumpage price in the long run is traced out in graphic form. The effect of price upon his regeneration method is interpreted in terms of annual per acre output on each of the four classes of conifer sites mentioned earlier. The basic yields on these sites are those derived in chapter 3 of this report and given in table 15. Figure 6 illustrates the relationship of a stumpage price range from \$40 to \$100 (1957-59 basis) per thousand board feet for one class of owner. Take as an example good site, where regeneration method is especially sensitive to prices because the possible gains from planting are so great. At the lower end of the range, the assumed stumpage price of \$40 would justify a relatively slight use of artificial (rather than natural) regeneration, and the average annual yield per acre is estimated at 424 board feet (table 15). At the upper end of the range, the greater interest in artificial regeneration that can be expected is estimated to promise an average yield of about 450 board feet. These average yields are for the good site forests of all exploitive owners taken as a group.

LONGRUN RESPONSE TO PRICE

OUTPUT PER ACRE PER YEAR
BOARD FEET, SCRIBNER RULE

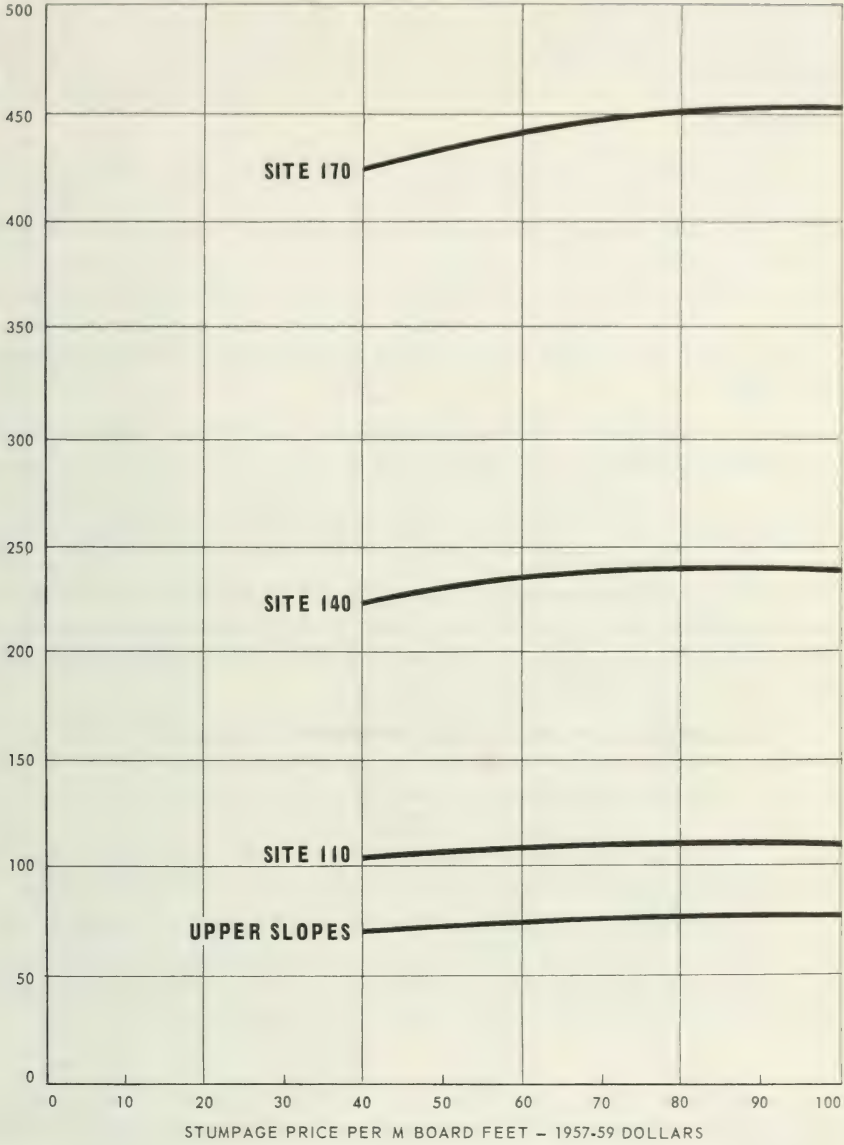


Figure 6.—Estimated longrun relation of timber output to prospective price level arising from regeneration practices on holdings of exploitive owners.

Forest site improvement.—The practice of forest site improvement, notably the application of chemical fertilizer to forest soil, may have a great potential influence upon timber management and timber output. In view of this possibility and despite the fact that supporting data are scant, it is essential in this analysis to take some account of fertilizers. Assumptions will therefore be made about the physical effects of fertilizers, and the calculation of economic influences will be based on these assumptions.

If some of the current estimates about benefits of forest fertilizers are near the truth, then it is just a question of time until fertilizers come into general use, and timber yields can be expected to increase greatly as a result. For example, it is sometimes estimated that with fertilizer as much timber can be grown in 50 years as would grow without it in 70—that is to say, that fertilizing can raise the annual per acre yield 40 percent. For middle site Douglas-fir under conservative management, such an increase would amount to more than 200 board feet per acre per year.

The assumptions to be used here are more cautious. A fertilizer program is assumed that calls for light applications at 5-year intervals, at a cost per application of \$10 (1957-59 basis) per acre. It is supposed that such a regime will increase the yield on high Douglas-fir site (index 170) by 10 percent, on medium site (index 140) by 17 percent, and on low site (index 110) and upper slopes by 35 percent. These percentages are chosen so as to represent an absolute increase in yield of about 100 board feet per acre per year on intensively managed Douglas-fir land—a little more than this on low sites, with their greater potentialities for improvement, and a little less on high sites.

The capitalized per acre cost of the assumed program is:

$$F + \frac{F}{(1+i)^f - 1}$$

where F is the per acre cost of one application, F is the frequency of application in years; and i is the forest owner's guiding rate of interest in decimals.

In a regulated forest that produces an annual harvest of thinnings and final cuts, if the extra yield of a fertilizer program augments the harvest gradually and in equal yearly increments during the first rotation, and thereafter is harvested in full, then the capitalized per acre value of this extra yield is:

$$\frac{I}{Ri^2} \cdot \frac{(1+i)^R - 1}{(1+i)^R - 1}$$

where I is the value of the full extra yield per acre per year and R is the rotation length in years.

For illustration, take the case of the conservative owner of an intensively managed Douglas-fir forest on medium site. In the absence of a fertilizer program, his rotation is 80 years, and his annual timber output is about 580 board feet per acre. Considering his 3-percent guiding rate of interest, his capitalized cost of fertilizing according to the assumed program is \$72.89 per acre. The

extra yield anticipated from the program is 98 board feet per acre per year. If the capitalized value of this extra yield per dollar of stumpage price (per thousand board feet) is computed by taking 1 in the expression as equaling 9.8 cents, the result is a capitalized per acre value of \$1.271. One concludes, then, that in order for the assumed fertilizer program to be financially attractive, stumpage would have to be worth at least 72.89 divided by 1.271, or \$57.35 (1957-59 basis) per thousand board feet, Scribner rule.

The minimum prospective stumpage value required to make the assumed fertilizer program attractive to each class of forest owner on each of four forest site classes is given in table 6. These values are all calculated for the hypothetical program that has been outlined. The forest rotation lengths and timber yields used in the calculation are those derived and explained in chapter 3 of this report and set out in table 15. It will be observed that fertilizing is the best bet on average Douglas-fir sites conservatively owned. Under conservative ownership, high sites offer lesser attractions because of the lower extra yields assumed, and low sites lose out because of longer rotations. Under intermediate and exploitive ownership, higher interest rates shorten the rotation and place the fertilizer program at a successively greater disadvantage. At a high interest rate, rotation length becomes the controlling element in the minimum stumpage value.

Timber-stand improvement and utilization.—The current and prospective level of stumpage values in relation to costs may be expected to bear directly on the attractiveness of all forms of timber-stand improvement carried out by harvesting or removing selected stems from the forest. The measures involved range from brush control in very young stands to the last commercial thinnings in stands nearing rotation age.

Table 6. — Minimum prospective stumpage value per thousand board feet necessary to attract a forest owner to undertake the assumed fertilizer program by class of owner and conifer site class.

Site class	Conservative owner	Intermediate owner	Exploitive owner
	- - - - -	<u>1957-59 dollars</u>	- - - - -
Douglas-fir site 170	62	115	300
Douglas-fir site 140	57	123	373
Douglas-fir site 110	59	138	420
Upper slopes	86	190	661

Measures that yield no immediate return in the form of merchantable wood derive their justification from prospective increases in output. For given increases and periods of waiting for them, a measure is justified if anticipated timber values are high enough in relation to treatment costs and if the interest rate is low enough. Measures that do yield an immediate return must pass the same test. However, the treatment cost in this case is rightly figured net of the immediate return, and consequently the latter, is high enough, may decide the issue in favor of the treatment, irrespective of the delayed extra yield so long as there is any. That is to

say, a "commercial" treatment of the stand, such as a commercial thinning, may be undertaken regardless of interest rate and prospective price.

Thus, in an era where stumpage values follow a horizontal trend, such as is here assumed for the long run, the level of value may exert its principal influence upon stand improvement practice, not so much through its effect on prospective value yields as through its effect on current wood utilization and on the question whether the improvement measure contemplated is a commercial treatment. It is assumed that at a \$40 sawtimber price the relation of wood values to conversion costs will permit utilization of all principal tree species at least to a d.b.h. of 5 inches and an inside bark top diameter of 4 inches. The stand-improvement regime expected under these circumstances, and the accompanying timber yields, is described at the beginning of chapter 3.

At prices higher than \$40—costs remaining the same—there is negligible room for increases in board foot yield. Cubic foot yield under a wood objective will be somewhat more strongly correlated with price through the influence of utilization.

Forest Taxation

The next timber management influences to be considered are property and income taxes. Discussion of inheritance taxes, which are an intermittent and relatively remote item of cost, will be postponed until the subject of forest ownership is taken up.

Property taxes: absolute amount.—Property taxes, like any cost item, may wield an influence upon a forest owner's timber management in two different ways. First, the absolute amount of the tax may affect his decision about owning the land or using it for timber production. Second, if the land is used for timber production, the relative amount of the tax levied when a certain management program is in effect (as compared with what the levy would be under some other program) may sway the owner's management decisions. Through both types of influence, forest property taxation may affect timber output.

As regards the absolute amount of the forest property tax, any tax that is high enough to extinguish the value of the land for forest use or depress it below the value for any other use—that is, to reduce the capitalized value of the forest property below its liquidation value—is confiscatory in the sense that it may lead the owner to liquidate the timber and either abandon the land or shift it to another use. For example, for the owner who uses a 4-percent interest rate and follows a 60-year rotation (table 3), gross timber yield (\$3.97) capitalized at 4 percent is about \$100 per acre. Timber liquidation value (col. 7) is about \$50. If taxes and other costs amount annually to more than about 4 percent of the difference, or \$2 per acre, they are confiscatory.

Short of confiscation, rising taxes reduce land values and put a hardship upon the current owner. They heighten the risks of forest management and raise the owner's guiding rate of interest, altering his program of output accordingly.

High taxes that are not confiscatory and are not expected to rise may become capitalized into land values and have negligible influence upon timber management. This is the state of affairs assumed for forest property taxation in the Douglas-fir subregion in the future, so far as the absolute amount of taxation is concerned.

Property taxes: relative amount.—With regard to the relative amount of the tax on a forest property under one management program as compared with another program, the influence at issue is that of changes in the amount of the tax per acre arising from changes in assessed value of the property, irrespective of changes in tax rate. There are two kinds of change in assessed value, with quite different effects upon timber management and output.

First, assessed value of a forest property may be changed in accordance with some change in the property that has not been planned or anticipated by the owner. For example, the assessment may be raised because of unexpected monetary inflation or lowered after an unavoidable forest catastrophe. Such changes in assessed value have no effect upon an owner's timber management or output because he can neither cause them nor escape them by altering his program.

Second, assessed value of a forest property may be changed in accord with the planned or foreseeable changes in the property. For instance, the assessment may be raised from year to year with increases in property value because of unharvested timber growth or lowered with decreases in value because of cutting. If a forest owner expects assessment changes of this kind, the expectation may influence his timber management because he can control the changes by means of his management practices. That is to say, there is a way for him deliberately to escape some of the tax, and he may be expected to take advantage of it.

To illustrate the point, consider again the Douglas-fir property of table 3 and the owner who has a 4-percent guiding rate of interest. If the property is assessed in the first manner described, so that the amount of the tax is essentially fixed in relation to the owner's management alternatives, then the tax is neutral toward management, and the timber program is the one previously indicated: to follow a 60-year rotation and grow about 400 board feet of timber per acre per year. On the other hand, if the property is assessed in the second manner described, so that the amount of the tax will vary directly with property value—i.e., with growing stock and growth—then the tax is not neutral: The tax rate is, in effect, subtracted from the rates of return in column 9, and the owner tends accordingly to follow a shorter rotation and produce a lower output, reduce his property value, and thus escape part of the tax.

Time bias in property taxation.—The feature of a property tax that leads to effects of the second kind is sometimes termed time bias in recognition of the fact that it stems from the manner in which the tax changes over time. A time-biased property tax necessarily tends to discourage forest conservation. It is time bias which has been mainly responsible for giving property taxation a bad name in forestry circles. Along with the absolute amount of the tax, time bias arising out of assessment practice (and not the annual feature of the taxation) is the crux of the so-called forest property tax problem.

The assumption made in this study is the same one made by optimistic forest owners in the Douglas-fir subregion: that inequities in the forest property tax, both in the amount of the tax and in its bias, will in future be discovered and eliminated; that procedures will be established for making the property tax neutral toward forest management.

Income taxes.—Unlike property taxes, income taxes tend generally to favor forest conservation. For the taxpayer, escape from the property tax lies in the direction of reducing his property: increasing immediate timber output at the expense of output later. But escape from the income tax lies in just the opposite direction: curtailing immediate timber output and income, accumulating the growing stocks, lengthening the rotation, and thus establishing conditions for ultimate higher yields.

Beyond the influences of any income tax upon timber management are the specific effects of the Federal tax, with its provisions regarding the treatment of long-term capital gains. One of these effects is to encourage the forest owner to incur silvicultural expenses that may be charged against his ordinary income. Another is to stimulate forestry investments in general because of the favorable treatment their revenues from timber will receive. The result is to favor an increase in the timber output of private forest owners, particularly in the long run. The effects of the Federal income tax law upon forest practices are most noticeable in the case of large-scale owners, both individual owners with upper-bracket income and corporate owners with wood-processing enterprises.

It is assumed for the purpose of this analysis that the features of the Internal Revenue Code will be retained.

Land Use

Up to now, this review of the influences upon timber output has dwelt on the subject of the timber management program—the practices followed on an owner's commercial forest lands. The review turns now to more general influences upon output: first, land use, in determining the entire extent of the commercial forest in the Douglas-fir subregion; and second, the ownership of this forest, in affecting the degree of conservation or exploitation to which the resource as a whole is subject.

Since the manner in which land use and commercial forest ownership affect timber output will be obvious, the discussion is confined to assumptions about the future status of these influences. Attention is directed to the year 2000. An effort is made to foresee some of the changes in land use and ownership that are most likely to come about in the intervening four decades. Where the trend of events is a major issue, a principal assumption and alternative assumptions are offered so that their effects upon output can be compared.

In the long run, still further shifts in land use and ownership are inevitable. However, it is believed that the general character and direction of longrun changes will reveal themselves within four decades and that no great purpose would be

served by attempting to project the trends beyond that period. Consequently, the land use and ownership assumptions for the year 2000 will be taken as applying both to the transition era and to the long run.

Consider now the use of the 35 million acres of land in the Douglas-fir subregion. In the decade of the 1950's, 83 percent of this land was in forest use; 73 percent (25-3/4 million acres) was commercial forest, suitable and available for timber production (table 7). Of the noncommercial forest land, amounting to 3-1/4 million acres, about two-thirds was reserved as National and State Parks, National Forest wilderness areas, and other tracts permanently or temporarily withdrawn from timber use; one-third was classed as noncommercial solely because of low timber productivity.

Lands other than forest lands amounted to 6 million acres, or 17 percent of the total. Nearly two-thirds of these nonforest lands was in farms. The remainder was in towns or other residential or industrial areas, in roads and rights-of-way, and in miscellaneous nonforest uses.

Table 7. — Major uses of land in the Douglas-fir subregion, decade of 1950's

Use	Thousand acres	Percent
Forest:		
Commercial	25,766	73
Noncommercial:		
Reserved	2,301	7
Nonreserved	980	3
All noncommercial forest	3,281	10
All forest	29,047	83
Nonforest:		
Farm, pasture, and range	3,968	11
Other nonforest land	2,085	6
All nonforest land	6,053	17
All land	35,100	100

What shifts in these acreages is it reasonable to postulate for the year 2000? Of the many alternative land uses, the seven discussed below are believed likeliest to have a measurable impact on timber production. Other land uses—such as military reservations, airports, and summer home sites—were considered but not included for analysis, primarily because their net impact was expected to be negligible. Possible interchanges will be considered between forest land available for timber growing and (1) forest land reserved for recreational use, (2) towns, (3) open farmlands, (4) roads, (5) power sites and rights-of-way, and (6) municipal reservoirs. Thought will also be given to (7) any lands, now classed as commercial forest, which are marginal because of precipitous terrain or very low site—lands whose contribution to the wood basket may therefore prove to be negligible. In this study, such lands are designated as "marginal commercial forest lands."

Recreational areas.—The areas considered here include under the multiple use concept: (1) what will be termed "vast areas," undeveloped tracts outside the boundaries of dedicated wilderness and wild areas, but formerly classified as limited areas, or presently as primitive areas, pending study and reclassification; (2) "developed areas," consisting of camp and picnic grounds; and (3) "protective strips" along roads and streams.

Except for dedicated wilderness and wild areas, it is assumed that there will be at least some logging of most multiple use areas having recreation designated as a dominant use, just as there will be other types of multiple use, including recreation, on other areas where timber production is designated as a dominant use. The actual pattern of use on any specific area will, of course, be determined by current policy and regulations, for example, as spelled out under the 1962 High Mountain Area policy statement.

The future need for and extent of vast recreational areas is a major issue in the West today. The importance of the issue to the subject of timber production in the Douglas-fir subregion is plain. Such areas range from several thousand to several hundred thousand acres each. Often they contain much productive forest land, so that an increase in their numbers can significantly affect timber output.

The type of vast area to be considered here is National Forest land which has been temporarily withheld from commercial timber use pending studies of its potentialities for recreational use. In the 1950's, there were more than 700,000 acres of such land in the subregion. The studies of these lands will not be completed for some time. Meanwhile, the principal assumption made here on the basis of a review of inventories of these lands, a large proportion of which appears to be well suited to timber growing, is that half of them will ultimately be dedicated to recreation as a special use and half of them made available for timber growing as the primary use.

However, the reserving of forest land for recreation is a sharp issue with an uncertain outcome. On the one hand, the demands for forest recreation are great and growing. On the other, national tastes in outdoor recreation may well shift away from vast, single-use forest areas and thus cooperate with the rising demands for timber-growing land. Consequently, two alternative assumptions are made here for later testing. They are liberal, contrasting assumptions: (1) An additional 1 million acres of National Forest lands will in the long run be taken from the commercial category and set aside primarily for recreation—over and above the recreational acreage allowed for in the principal assumption; (2) one million acres of forest land counted as reserved mainly for recreation in the principal assumption will instead be available without restriction for timber growing. A million acres represents about 4 percent of all today's commercial forest land in the Douglas-fir region. But since the sites involved are below average, the fraction of timber output represented is smaller than 4 percent.

The next type of recreational land to consider is the developed area, the camp or picnic ground.

For the National Forests, it has been estimated that by the year 2000 the acreage requirement for developed areas for the United States as a whole will be about eight times what it is today. It is assumed that somewhat this same ratio applies in the National Forests of the Douglas-fir subregion and that 124,000 acres of currently commercial forest land will be reserved for camp and picnic grounds during the next four decades.

For State-owned lands, general forecasts and plans of the park departments suggest the assumption that 84,000 acres of commercial forest will be set aside as developed areas. For other public lands, mainly county and municipal lands, no allowance is made for shifts on account of developed areas. Apparently most of the prospective recreational developments in this case will be on nonforest land, so that forest acreage requirements will be negligible.

For private forest lands, it is again assumed that no allowance need be made for the reservation of developed areas. It is true that a few of the larger wood-using concerns are now providing picnic and campgrounds and that this practice may well be extended. But it is doubtful that such areas will be permanently located. It is likely that they will be rotated to avoid damage to trees and soil. Timber production is the source of these companies' livelihood, and nonrevenue-producing land uses may be expected to remain secondary and not be allowed to interfere seriously with the growing of timber. The picture would change, of course, if forest recreation were on a pay-as-you-go basis.

Finally, there are the protective strips along roads and streams. A considerable mileage of such strips has been reserved in the past, especially by the public landowners. In the future, however, it is expected that reservation policies will be modified. Further wholesale withdrawals are unlikely. Probably new withdrawals will be made only where scenic values are dominant. The resulting subtractions from commercial forest may be at least counterbalanced by sanitation and salvage cuttings in many of the protective strips. It is therefore assumed that no allowance need be made for further reductions in potential timber output on account of such strips.

Urban lands.—Current changes in the acreage of urban land show the results of at least two contrary influences. On the one hand, there is the phenomenon known as urban sprawl, a determined flight of families to the suburbs and the establishment of "bedroom" communities. On the other hand, families are returning to the city to escape the higher cost of suburban services, added expenses such as that of owning two cars, and the loss of time in commuting. It is quite likely that, in the next few decades, cities will absorb expected population increases not so much by further sprawl as by filling in vacant spaces within city limits, using the extensive areas between suburban developments and redeveloping or renewing old, rundown neighborhoods to provide multiple-family dwellings in an attractive setting. Urban expansion will impinge on other land uses, mostly the farm uses.

It is assumed that the commercial forest use will not be significantly affected within the coming four decades.

Open farmlands.—Farms in the Douglas-fir subregion will be called upon for increasingly large outputs as time goes on. Probably there is a great deal of forest land in the subregion that is suitable for farming. However, there is good reason to believe that larger farm output between now and the end of the century will not be gained at the expense of the forest: that no allowance need be made for shifts from commercial forest to farm use.

Farm acreage in the subregion reached at least a temporary peak in 1950 and is now declining in all districts except the Southwest Oregon (fig. 7). Indications are that there, too, a decline will soon commence. What is happening is that improvements in agricultural technology are making it possible to grow heavier crops on the best lands and are rendering many of the poorer lands submarginal, even in the face of rising demands. Farms are being abandoned in agricultural fringe areas bordering the forest zones. On other farms, owners are doing some forest planting—on their own initiative or with encouragement from the Government.

Trends toward farm contraction may not continue indefinitely, but if they are reversed, there will still be a large acreage of abandoned fringe lands to reoccupy before any net encroachment upon today's commercial forest becomes necessary. The fringe lands will also act as a cushion to absorb, directly or indirectly, the farmers that may be displaced from urban zones.

Roads.—Even a casual observer of the forest economy in the subregion will note that roads must account for a significant reduction in commercial forest area. Two classes are involved in this reduction: (1) forest highways, either State or Federal, which cut through forested lands, and (2) all other forest roads, including county roads and roads constructed specifically for forest purposes such as logging, silviculture, and protection.

As for forest highways, the east-west highways across the Cascades are the ones that take the most forest land at present. Some of the north-south highways also cut through forest land, but their impact is not as great since they follow the valleys. Nearly all the feasible cross-State routes are established. Expected changes during the next four decades amount to realigning present highways, eliminating curves, and perhaps widening some stretches. Eliminating curves and shortening distances are expected largely to offset the taking of additional land in widening rights-of-way, so that the net impact of changes on commercial forest land is expected to be negligible.

As for forest roads other than highways, this use of land will probably have a major impact on the acreage of commercial forest. In fact, it is expected to account for the biggest reduction in all classes of forest ownership in each of the three districts. The reduction will come from two sources. First, the surveyed acreage of commercial forest, such as that given in table 7, includes all rights-of-way less than 2 chains wide. That is to say, forest highways have been deducted from the acreage figures, but the present network of forest roads less than 2 chains

FARMS and FARM WOODLAND

MILLIONS OF ACRES

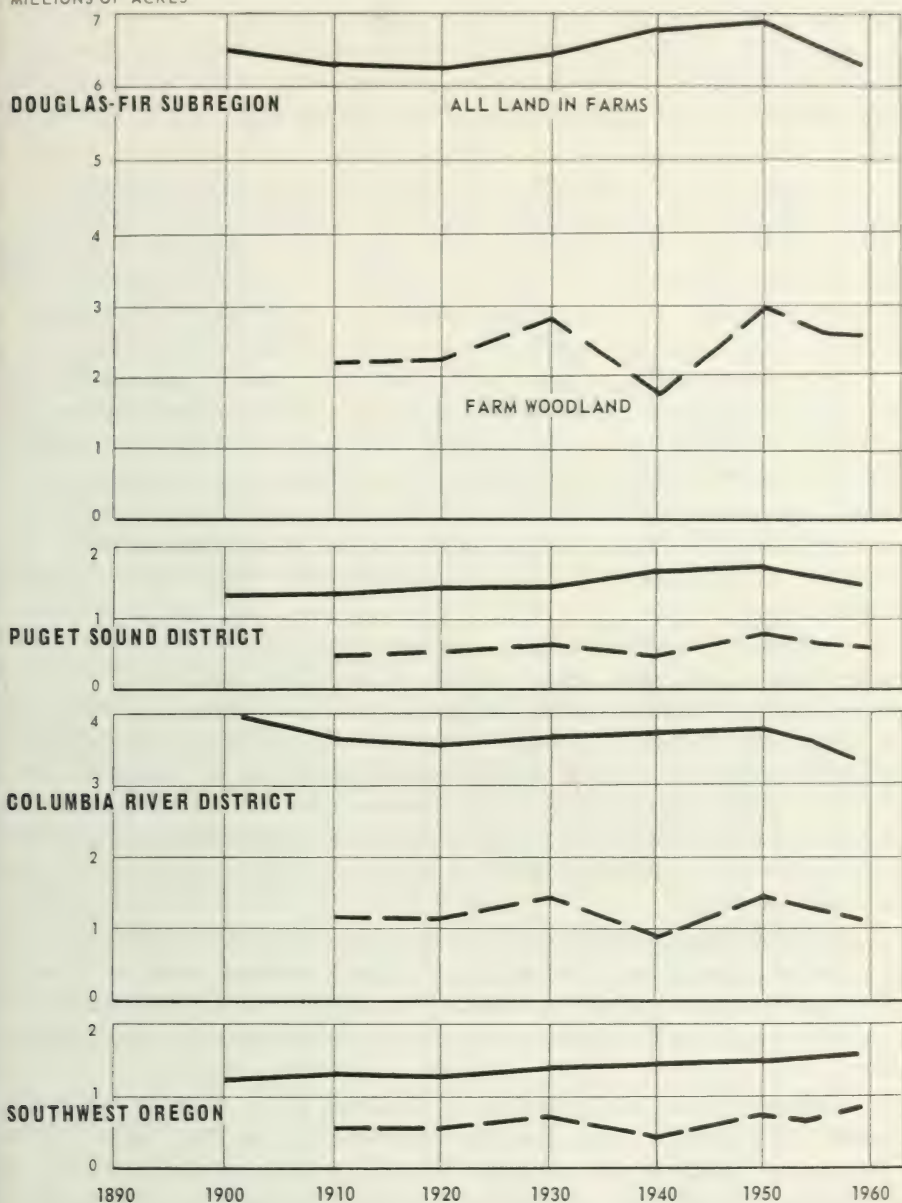


Figure 7.—All land in farms and farm woodland in the Douglas-fir subregion and its three districts, 1900-59. (Basis: U.S. Census of Agriculture. Farm woodland acreages for 1940 are inconsistent with other data in the series because of the forest-land definition used in the 1940 census.)

in width has not been subtracted and must be taken out to arrive at a net figure. Second, the present network of forest roads on all lands except the small private holdings is not adequate for the sort of management expected to be in effect by the year 2000. Present density on all but a few of the most intensively managed lands probably does not exceed 1-1/2 or 2 miles of road per square mile of forest land. In this study, it is assumed that a density of at least 5 miles of road per section will be reached.

In computing how much land will be taken for forest roads, an average right-of-way width of 55 feet is assumed. However, it is assumed that not all the right-of-way will be lost to timber production, since crowns and roots of trees will extend into it. It is estimated that crowns and roots will be able to make use of 10-foot strips on each side. On this basis, the subtraction of commercial forest land on account of roads comes out to 845,000 acres for the subregion as a whole.

Power developments.—Another type of withdrawal that is expected to have a noticeable impact on the subregion's timber production potential is power development, including dam sites, reservoirs, and powerline rights-of-way. With the big upsurge in the building of Federal projects during the last 20 years, a considerable amount of timberland has been inundated. And after Bonneville Dam was finished in 1938, a network of transmission facilities was begun that now accounts for the withdrawal of at least as much timberland as has been taken by reservoirs.

Bonneville Power Administration estimates that by about 1970, all economically feasible major dams and reservoirs will have been completed in western Oregon and Washington. These installations probably will not take so much land as did those of the past 20 years. It is expected that other power sources, such as atomic energy, will then be more economical than remaining hydroelectric possibilities. If all the prospectively feasible dams are built, the resulting additional withdrawals of commercial forest land will amount to possibly 30,000 acres. Most of this land will be in the Columbia River district. Very little will be in the Southwest Oregon district.

Municipal reservoirs.—This topic concerns not watershed lands generally but only the lands inundated by reservoirs. Municipal watersheds today are in many cases used for timber as well as for water production, and it is assumed that in future the means will be found for carrying on the two uses together with negligible interference.

Reservoirs for municipal water supply account at present for only a very small reduction of commercial forest area, probably not more than 5,000 acres. Future needs in the subregion up to the year 2000 should not require more than six times the present acreage, even allowing for greater per capita use of water as well as for population increases. The economics of building storage reservoirs in remote locations and of bringing water to population centers may well become increasingly questionable. The cost of the necessary facilities will probably compare less and less favorably with other means of obtaining water, such as purifying river water and desalting sea water.

Marginal commercial forest lands.—Included in the current inventory of commercial forests is a considerable acreage of very rough, low-site land, the timber potentialities of which are highly uncertain. In the interest of caution, this marginal commercial forest land, estimated at 139,000 acres for the whole subregion, is excluded from future commercial forest estimates. The excluded lands are believed to fall almost entirely in three classes of holdings: National Forests, other Federal lands, and large private holdings.

Land use in relation to timber value.—The estimate of future commercial forest-land acreage implied in the foregoing assumptions about alternative land uses is meant to be valid at a stumpage price of about \$40 per thousand board feet. At lower prices, and certainly at very low prices, larger subtractions from the commercial forest column can be expected on account of most of the alternative uses. What is of greater interest in this study, the longrun expectation of higher timber prices would probably result in some land use changes in favor of timber growing. The likeliest source of new timberlands would be the less productive farms of the subregion. A review of the acreages involved by type and size of farm leads to the estimate that, other things equal, a timber price expectation of \$100 (1957-59 basis) per thousand board feet would bring into timber use no more than 750,000 acres of farmland. Nearly all this shift in land use would take place in the Puget Sound and Southwest Oregon districts: close to four-tenths of it in the former district and six-tenths in the later.

Forest-Land Ownership

Attention is shifted now from the general topic of land use as a determinant of future timber output to the more specific subject of commercial forest land and its ownership. How forest ownership can influence timber output was given some thought earlier in chapter 2. Here, the questions to be considered are the present ownership of commercial forest land and the probable future ownership of the land that will then be commercial forest. In assumptions about the future, the year 2000 is again used as the date of reference.

A major simplifying assumption to be made is that, apart from such changes as will be caused by shifts in land use (primarily in connection with roads and reserved areas), there will be no changes in the public ownership of commercial forest land. That is to say, it is assumed that there will be no net transfers of commercial forest among public owners or between them and private owners. Consequently, attention will be devoted mainly to the classes of private forest owners—their holdings today and the changes that may take place among them in the future.

In the Douglas-fir subregion as a whole in the mid-1950's, private owners held about 13.3 million acres of commercial forest land, slightly more than half of the 25.8-million-acre total. Of the private commercial forest, almost half (46 percent) was in small holdings, less than 5,000 acres apiece. Large holdings, comprising more than 50,000 acres, made up 41 percent of the total. The remainder, 13 percent, was in holdings of medium size. The acreages for the subregion and its districts are set down in table 8, where they are further subdivided by what

are termed "type-site classes." These classes, which are essentially forest productivity classes, are brought into the record at this point so that their ownership can be traced henceforth and they can be used as a basis for judging the potential timber yields of the future. The kind of forest included in each class is explained briefly at the foot of table 8 and fully in the introduction to Appendix A.

Large private holdings made up 49 percent of the privately owned commercial forest land in the Puget Sound district (table 9) and thus predominated over other size classes in that district. In the Columbia River district, however, large holdings occupied less total acreage than small, and in the Southwest Oregon district they constituted a mere three-tenths of the private acreage. Small- and medium-size holdings, on the other hand, increased in relative importance from the north to the south end of the subregion, both being most extensive in the Southwest Oregon district. In all three districts, the medium-size properties made up the least acreage.

Table 8. — Commercial forest-land acreage in the Douglas-fir subregion, by district, owner class, and forest type-site class; decade of 1950's

(In thousand acres)

ENTIRE SUBREGION							
Type-site class ¹	Private holdings			Public holdings			All holdings
	Large	Medium	Small	National Forest	Other Federal	Other	
1	2,779	618	2,062	1,328	867	1,051	8,705
2	1,708	529	1,938	1,849	954	649	7,627
3	578	379	1,174	2,480	611	388	5,610
4	93	48	40	1,687	69	114	2,051
5	290	169	907	149	71	187	1,773
All	5,448	1,743	6,121	7,493	2,572	2,389	25,766
PUGET SOUND DISTRICT							
1	949	93	471	173	9	318	2,013
2	576	77	580	416	45	245	1,939
3	353	130	447	617	55	293	1,895
4	36	12	12	521	15	100	696
5	228	51	406	18	28	107	838
All	2,142	363	1,916	1,745	152	1,063	7,381
COLUMBIA RIVER DISTRICT							
1	1,263	403	1,086	954	255	666	4,627
2	915	272	849	956	325	333	3,650
3	163	93	337	927	255	87	1,862
4	54	12	26	664	24	12	792
5	46	65	411	60	23	74	679
All	2,441	845	2,709	3,561	882	1,172	11,610
SOUTHWEST OREGON DISTRICT							
1	567	122	505	201	603	67	2,065
2	217	180	509	477	584	71	2,038
3	62	156	390	936	301	8	1,853
4	3	24	2	502	30	2	563
5	16	53	90	71	20	6	256
All	865	535	1,496	2,187	1,538	154	6,775

¹ Principal forests in each class: 1.—Douglas-fir on sites I and II (average index, 170). 2.—Douglas-fir on site III (140). 3.—Douglas-fir on sites IV and V (110). 4.—Upper-slope mixtures. 5.—Hardwood types on all sites. For full explanation, see Appendix A.

Table 9. — Proportions of the private commercial forest land in each district of the Douglas-fir subregion that fall into each size class of holding, decade of 1950's (In percent)

District	Large holding	Medium holding	Small holding	All private holdings
Puget Sound	49	8	43	100
Columbia River	41	14	45	100
Southwest Oregon	30	18	52	100
All districts	41	13	46	100

The small private forest holdings are about equally divided between farm and nonfarm ownership in the subregion as a whole, and in the Puget Sound district, also, the acreages of the two groups are not greatly different (table 10). However, in the Columbia River district there is nearly twice as much farm woodland as nonfarm in small holdings, while in the Southwest Oregon district, the proportions are reversed. Some of the causes of this are discussed later, where the farm-nonfarm distinction is used in tracing probable future trends in the small forest holdings.

Another useful means for describing the small holdings is a subdivision by size class. The range of sizes below 5,000 acres covers, after all, a very wide variety of situations. For example, the 10-acre plot is quite a different kind of forest, with possibly a much different future, from the 4,000-acre tract. Acreages subdivided into four size classes are given in table 11. When the varying range of these classes is taken into account (a range of 90 acres in the smallest increasing to 3,000 acres in the largest), it becomes evident that the distribution of holdings is heavily skewed toward the smallest ones: the class from 10 to 99 acres is the most prominent—in acreage and, of course, in numbers. The increasing prominence of the smaller classes is most marked in the Puget Sound district, least so in the Southwest Oregon.

Table 10. — Commercial forest land in small private holdings in the Douglas-fir subregion, by farm and nonfarm ownership and district; decade of 1950's (In thousand acres)

District	Farm holdings	Nonfarm holdings	All small holdings
Puget Sound	824	1,092	1,916
Columbia River	1,734	975	2,709
Southwest Oregon	480	1,016	1,496
All districts	3,038	3,083	6,121

Table 11. — Commercial forest land in small private holdings in the Douglas-fir subregion, by size class and district; decade of 1950's
(In thousand acres)

District	Size class				
	10-99 acres	100-499 acres	500-1,999 acres	2,000-4,999 acres	All classes
Puget Sound	766	825	287	38	1,916
Columbia River	731	1,219	569	190	2,709
Southwest Oregon	254	643	404	195	1,496
All districts	1,751	2,687	1,260	423	6,121

What changes in the present pattern of private commercial forest-land ownership may reasonably be expected during the next four decades? This question will be explored first with an eye to the large private holdings and then to the medium and small holdings.

Large holdings.—One of the most dramatic trends in the forest economy of the Douglas-fir subregion today is the growth of the large land holdings. In progress ever since the turn of the economic tide in the mid-1930's, this current growth of big holdings reached its highest rate in the years following World War II. Some of the growth has taken place as forest owners with tracts of medium size have, through acquisition of other medium-size and of small forest properties, expanded above the 50,000-acre mark. But the bulk of it has occurred through the enlargement of properties already in the big class. Most owners of such tracts, typically diversified wood-manufacturing corporations, have carried on vigorous land acquisition programs, buying up both contiguous and scattered holdings in the small and medium classes within what they considered to be their operating territories. Many private forest owners have been approached by one or more of these big buyers and know quite clearly to whom they could sell their land, and at what price, if they choose to do so.

Besides the flow of private forest lands from the small and middle categories into the large holdings, there have been some mergers between big holders that have heightened the concentration of ownership. Thus, while the large properties have exhibited great increases in acreage, they have shown no significant increase in numbers. In the mid-1950's, there were fewer than 30 of them in the Douglas-fir subregion: about four-hundredths of one percent of the private forest owners, holding four-tenths of the private commercial forest land.

The growing concentration of private forest ownership in the Douglas-fir subregion may be regarded as one aspect of the whole trend toward bigness in American economic life. Just as this trend is widely expected to continue in force, so the growth of forest concentration may be regarded as a continuing feature of Douglas-fir country, though the rate of growth will very possibly not be so high in future as it was in the first decade after World War II.

Concentration of forest ownership is the evidence and the result of the inherent strength of big owners, notably those whose ownership is integrated with the operation of diversified wood-manufacturing plants. With their low guiding rates of interest, fortified by their long view of the future as corporations, these big owners tend to set a higher value upon forest land than do other owners, a value which is reflected in their successful bidding in the land market. This advantage is strengthened by their diversification and by their ability to employ specialized technicians, both of which permit them to realize the full value of the land's timber products. To the extent that they enjoy economies of scale in manufacturing and product distribution, these economies prompt them to secure the essential raw material sources by means of enlarged forest ownership. Their increasing bigness helps them increasingly to spread their risks, to gain certain income tax advantages, and to afford the use of extensive landownership as a hedge against general monetary inflation.

However, as the concentration of private forest ownership continues, it meets—and will meet—increasing resistances. The most obvious and forceful of these resistances is the continuously greater strength of the other forest owners who remain, whose properties must be bought if concentration is to progress further. Forest-land prices rise, while the average quality and desirability of purchasable tracts decline. Competition for forest land becomes a noticeable element in the market. The big owner who has been buying up farms in fringe areas finds himself increasingly at odds with the farm interests who fear the loss of a base sufficient to maintain essential community and agricultural services. The corporation that has bought more than a certain critical fraction of the land in a county may thereby acquire hard problems in public relations and in property taxation. And always, as a firm's size grows, the dangers increase of its running against Federal antitrust policy.

What is foreseen, then, is a continuing but slackening increase in the acreage of commercial forest in large private holdings. The future trends assumed vary somewhat from district to district within the Douglas-fir subregion.

The Puget Sound district has an older forest economy than either of the other two. Forest industry became generally established earlier and is now more diversified. Processing is carried to higher levels of refinement. Apparently, under the press of dwindling raw material supplies, industry was early forced into the protective measure of acquiring large blocks of timberland. Large-scale owners now hold half of the private commercial forest. The possibility of further concentration is limited. Holdings of medium size, which ordinarily are prime land for acquisition, have been reduced to well under a tenth of the private forest acreage and now constitute to some extent an unapproachable hard core. Remaining farm woodlands, too, are believed to be a relatively permanent class. Any further increase in the large holdings must come principally from the small nonfarm tracts, which make up about a fourth of the private commercial forest land, though here the great proportion of very small tracts (table 11) presents a barrier to their acquisition.

In the Columbia River and Southwest Oregon districts, and particularly in the latter, wood-industry development is less advanced. As management of the forest resource becomes more intensive in western Oregon, these two districts are expected to experience somewhat the same shifts in forest ownership as will have already occurred in the Puget Sound district: increases in large holdings, heavy reductions in small nonfarm tracts, moderate reductions in the medium class, and light reductions in form woodland.

The net result of these expectations is tabulated at the end of this chapter, following some further analysis of the situation on the medium and small forest properties.

Medium and small-nonfarm holdings.—To turn from the big holdings to the small nonfarm tracts is to shift at once from examples of the strongest private forest ownership in the Douglas-fir subregion to examples of the weakest. The small nonfarm and the medium-size properties are here grouped, not because their stories are just the same but because they have some characteristics that differ in degree rather than in kind. For example, so far as outlook for the future is concerned, the medium holdings that are owned in integration with a sawmill (the typical case) grade imperceptibly into the holdings of less than 5,000 acres that are similarly owned. And the small, unintegrated, individually owned tract has its close counterpart in the size range above 5,000 acres.

Consequently, where this discussion treats one particular size group or the other, it must be interpreted as applying to some extent also on the opposite side of the 5,000-acre boundary.

The situation of many middle-scale forest owners is reflected in the remarks of one lumberman, the third-generation manager of his family's woods and mill business. "We are too big to get real savings of overhead," he says, "and too small to diversify; and we can't expand because we must hold our earnings in liquid form to be able to pay inheritance taxes."

This firm owns 20-odd thousand acres of timberland, not enough for permanent operation of its mill. Right after the War, it bought several small tracts to enlarge its holdings, but now land prices have been pushed up beyond what it can reasonably afford. Entering the market for Government timber, it finds itself consistently outbid both by little independent loggers and big companies. The manager believes that if he could add a veneer lathe, stud mill, and chipper he might be able to pay \$12.50 more per thousand feet for stumpage. What he would like most is a pulpmill, but this appears to be out of reach, even as a cooperative venture with the other medium-size concerns in the area.

He has standing offers for his forest land from his two largest competitors. The price is high by comparison with the earnings that he himself is able to make from the land. His sense of family obligation has kept him going. Nevertheless, he believes that to sell out is inevitable, if not in this generation then surely in the next, for his sons have shown no great enthusiasm or aptitude for the lumber business.

Small nonfarm forest properties give some evidence of being even more weakly held than properties of middle size. They are almost always owned by individuals, and consequently tenure and the policies applied to these properties have little continuity. They are apt to come on the market at least once each generation, and many of them change hands much oftener. The tendency of the market is to transfer these tracts little by little into stronger ownership, which may well mean incorporating them into big holdings.

Most of the small nonfarm forests are too small for any effective integration with other enterprises such as manufacturing. This fact, taken with the uncertainties that face the small-scale timber seller and the technical handicaps under which he operates both in growing and in marketing timber, creates a strong financial disadvantage for the owner. The size of his tract presents also serious problems in organization and administration for timber output—as, for example, the irregularity, small quantity, and intermittent nature of the harvest.

Many owners of small forest properties, it is true, are primarily interested in values other than timber—for instance, recreation or the mere pleasure of land ownership. But such owners, too, have problems, which they share with those who are timber oriented—problems of protecting and managing the property from a distance and of financial insecurity.

Thus, taking nonfarm forest holdings as a broad class, one is impressed by the number and strength of the forces working toward consolidation of these holdings into larger and larger units.

Future trends of consolidation may be expected to differ among the three districts of the Douglas-fir subregion. In the Puget Sound district, for reasons touched upon earlier, the outlook is for comparatively small further changes. Along with the fact that the forest economy of the district is the most advanced, there is the circumstance that markets for wood, including pulpwood, are in general more highly developed and therefore more favorable to timber management on smaller tracts. In the Columbia River district, there is more opportunity and prospect for ownership changes toward consolidation; and in the Southwest Oregon district there is the most of all.

Small farm holdings.—The farm forest holdings, in contrast to the small forest properties that are not a part of farms, must be regarded as among the more stable and permanent features of the landownership pattern. Their permanency is in part fortuitous: Physically attached to farms, many of them cannot very well change class of ownership unless the farm is abandoned, no matter how little regard the owner may have for their management. But the relative permanency of the farm forests arises also out of certain inherent advantages in administration: notably the opportunity for integration with other farm enterprises and for joint use of labor and equipment.

Farm forests share the advantage of farmlands generally in the Douglas-fir subregion that they change hands less frequently than nonfarm rural properties.

In a survey of small woodlands, both farm and nonfarm, it was found that 63 percent of the farm tracts, as against 43 percent of the nonfarm, have been owned by the same person for 20 years or longer. In a sample about equally divided between farm and nonfarm owners, only 15 percent of those who expressed the intention of selling their land were farmers.

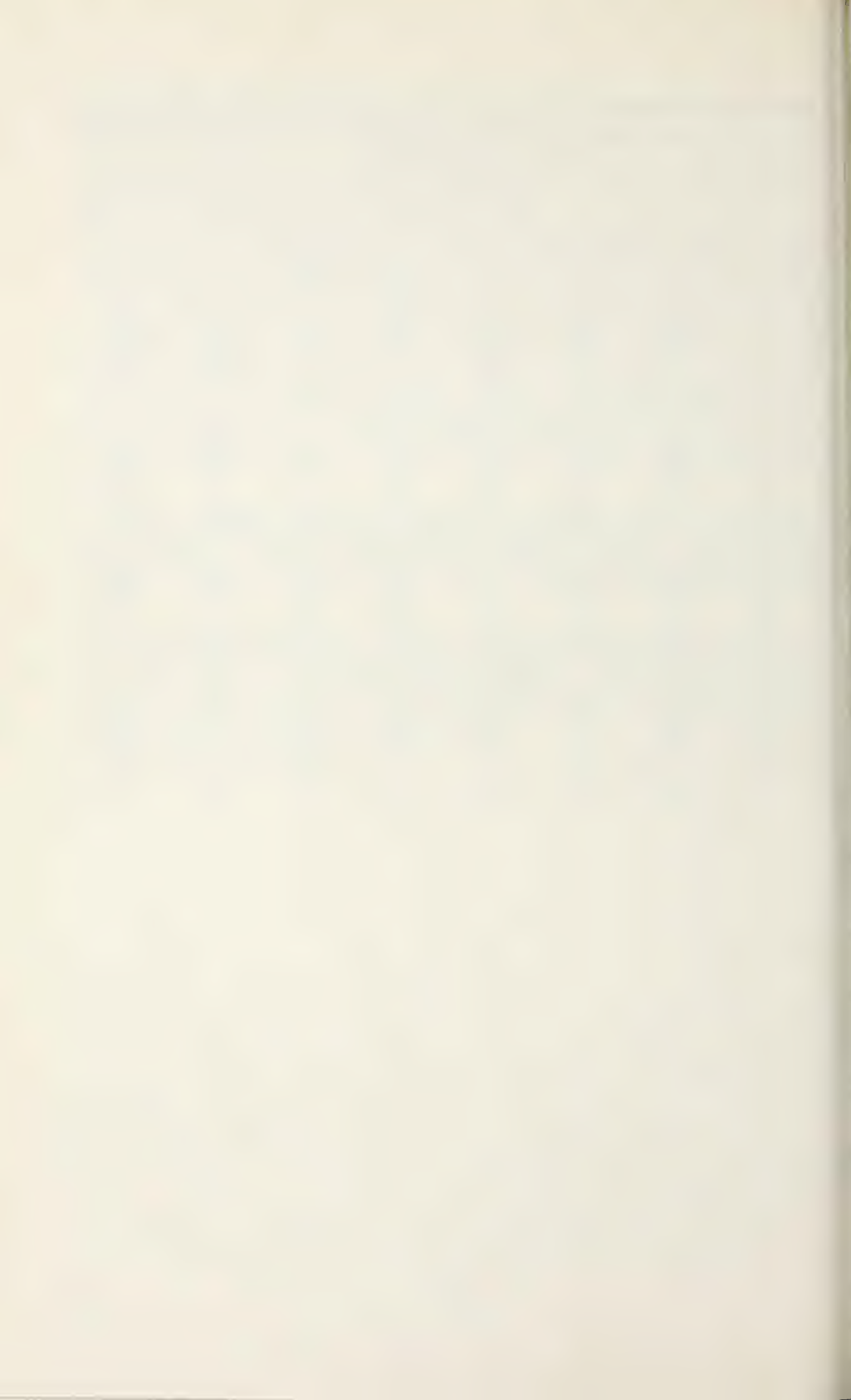
Furthermore, the farmers of the Douglas-fir country, unlike those in some other regions, appear very generally to take a strong interest in their timber resources. They observe at first hand that timber is one of the principal bases of rural economic life. They often have outside experience as woods workers. And they frequently find that their forest land, when devoted to timber growing, is one of the more productive parts of their farm. Although timber income is but a small part of aggregate farm income in the subregion, it is an important part on many farms. As a result, farmers tend to be reluctant to give up their forest land, even when it is so situated that it could be acquired advantageously by larger timberland owners.

There is expected to be only a slow drift of commercial forest acreage out of farm ownership into nonfarm, principally into the large holdings. Again the drift bids fair to be most pronounced in the Southwest Oregon district, least in the Puget Sound.

The net result of all anticipated shifts in ownership of commercial forest land during the coming four decades is set down in table 12. This table may be compared with table 8, which describes the current situation. Table 12 accounts for prospective changes in land use, under the principal assumptions described earlier, as well as for the changes in ownership.

Table 12. — Commercial forest land acreage in the Douglas-fir subregion, district, owner class, and forest type-site class—principal assumption for the year 2000
(In thousand acres)

ENTIRE SUBREGION							
Type-site class	Private holdings			Public holdings			All holdings
	Large	Medium	Small	National Forest	Other Federal	Other	
1	4,712	156	390	1,223	836	991	8,308
2	2,991	230	813	1,769	922	601	7,326
3	796	220	1,031	2,434	584	355	5,420
4	86	46	39	1,770	66	96	2,103
5	274	159	874	125	68	170	1,670
All	8,859	811	3,147	7,321	2,476	2,213	24,827
PUGET SOUND DISTRICT							
1	1,283	98	75	154	9	302	1,921
2	932	76	181	406	44	229	1,868
3	331	127	432	615	52	278	1,835
4	34	12	13	585	15	94	753
5	217	48	392	15	27	100	799
All	2,797	361	1,093	1,775	147	1,003	7,176
COLUMBIA RIVER DISTRICT							
1	2,378	38	230	896	245	632	4,419
2	1,270	148	548	907	313	310	3,496
3	155	89	326	896	244	77	1,787
4	50	12	24	666	22	2	776
5	42	61	396	43	22	64	628
All	3,895	348	1,524	3,408	846	1,085	11,106
SOUTHWEST OREGON DISTRICT							
1	1,051	20	85	173	582	57	1,968
2	789	6	84	456	565	62	1,962
3	310	4	273	923	288	--	1,798
4	2	22	2	519	29	--	574
5	15	50	86	67	19	6	243
All	2,167	102	530	2,138	1,483	125	6,545



Chapter 3

Timber Yields in the Long Run

The purpose of this chapter is to work out some estimates of the annual yields of timber that might economically be produced in the Douglas-fir subregion in the long run. The purpose is to figure annual yields under different assumptions and thereby to test the effect of alternative developments upon the yield. In the course of these conjectures, the question of what timber rotations and management measures are economical will also be touched upon, by way of following up the principles explored in chapter 2. Thus, in a sense this chapter is a study of the long-run timber supply, and its object is to consider the contribution to the national timber supply that the Douglas-fir subregion might appropriately make in the long run.

To analyze longrun timber yields, the following steps will be taken: First, the economical yield per acre will be worked out, under one set of assumptions regarding revenues and costs, for the conservative forest owner with a saw log objective. Second, economical per acre yields will be estimated, under single sets of assumptions, for other classes of owners with a saw log objective and for each class with a wood objective. Third, the foregoing per acre yields will be translated into total annual yields for the Douglas-fir subregion under a single set of assumptions regarding land use and forest ownership. Fourth, the total timber supply of the subregion will be analyzed in relation to alternative sets of assumptions. Fifth, the implications of the findings will be studied.

Economical Yield Under Conservative Management

Take the case of the conservative owner of a tract of type-site 2 forest (Douglas-fir, site III). Suppose that such an owner plans a management program for continuous saw log production. An even-aged silvicultural system is to be followed, with light intermediate cuttings beginning early enough in the life of each stand, and continuing frequently enough, to permit high utilization of the site. After the final harvest cut, prompt regeneration of a good quality stand is to be assured by whatever means are necessary. The forest is to be managed under close professional supervision. It is to be provided with a road network, or equivalent means of access, to the high standard described in chapter 2. All trees 6 inches and larger, d.b.h., are to be utilized to a 4-inch top; and losses from fire and other agencies will be held to a negligible level. Neither fertilization nor pruning will be practiced. Value growth arising from conversion and regeneration cost differentials will amount to 1 percent annually, but there will be no other trend in unit value to affect this growth: the prospective value will be \$40 (1957-59 basis) per thousand board feet, Scribner rule, in the terms of figure 5. How much timber can this owner be expected to produce on the average acre in the long run?

Growth of managed young timber.—The first question to answer concerns the timber growth that can be expected under the prescribed management program. Since growth will vary with stand age and also with the amount of growing stock carried between intermediate cuts, growth must be estimated in relation to both these variables.

Incidentally, to assume that growth at any age is related to growing stock is neither to affirm nor to deny the so-called plateau effect: that above a certain minimum stocking (often said to be about half of the maximum that the site is capable of carrying at the stand age in question), the well-spaced stand utilizes the site fully, so that total annual growth of organic matter is fixed. This study is concerned with the growth, not of all organic matter, but of merchantable timber. Furthermore, if even an approximate plateau exists, then the location of the edge of the plateau becomes a matter of great concern, since, as will soon become evident, it will probably fix the economical level of stocking for a wide range of owners. That is to say, the question of the growth-stock relationship is as generally pertinent as that of the growth-age relationship.

No one knows for sure the relation of Douglas-fir growth to stand age and stocking under intensive management. The best that one can do is to gather the available evidence from the Douglas-fir subregion and from European records and interpret it as he can. Such an interpretation was made by Briegleb (2) in 1952. Additional data are to be found in the more recent published work of Grah (3) and Smith (9). This study begins with Briegleb's findings, tempers them with the published and unpublished data that have become available since 1952, and converts the result into the units of measure required here. For forest type-site 2, the board-foot growth derived by this approach is given in figure 8. The basic estimates in both board feet and cubic feet for all type sites are detailed in tables 33-40, Appendix B.

To study the meaning of figure 8, take the 60-year curve as a case in point. This curve shows a current annual growth of about 700 board feet (Scribner rule) per acre in a stand of 10,000 board feet per acre. Such a stand is a little more than 40 percent stocked in terms of the normal yield table. The curve reading represents an estimate that if an acre of Douglas-fir on site III is thinned from an early age in such a manner that at age 60 it supports 10,000 board feet as well distributed as possible, stemwise, for utilization of the site, the current (gross) growth will be about 700 board feet per year. Likewise, by reading the same curve at 20,000 feet, one obtains the estimate that if a stand is brought up through a thinning regime (clearly, a different regime from the one foregoing) to a volume of 20,000 feet per acre at 60 years, so distributed that the site will be used as fully as possible, then the stand's current annual growth will be about 1,330 board feet per acre. Thus the positions along the 60-year curve do not represent immediate alternatives for the forest owner—he cannot take a 60-year-old growing stock of 20,000 feet per acre growing at the rate of 1,330 feet annually, cut out half the volume, and expect the residual to grow at a 700-foot rate. However,

CURRENT ANNUAL GROWTH

BOARD FEET, SCRIBNER RULE

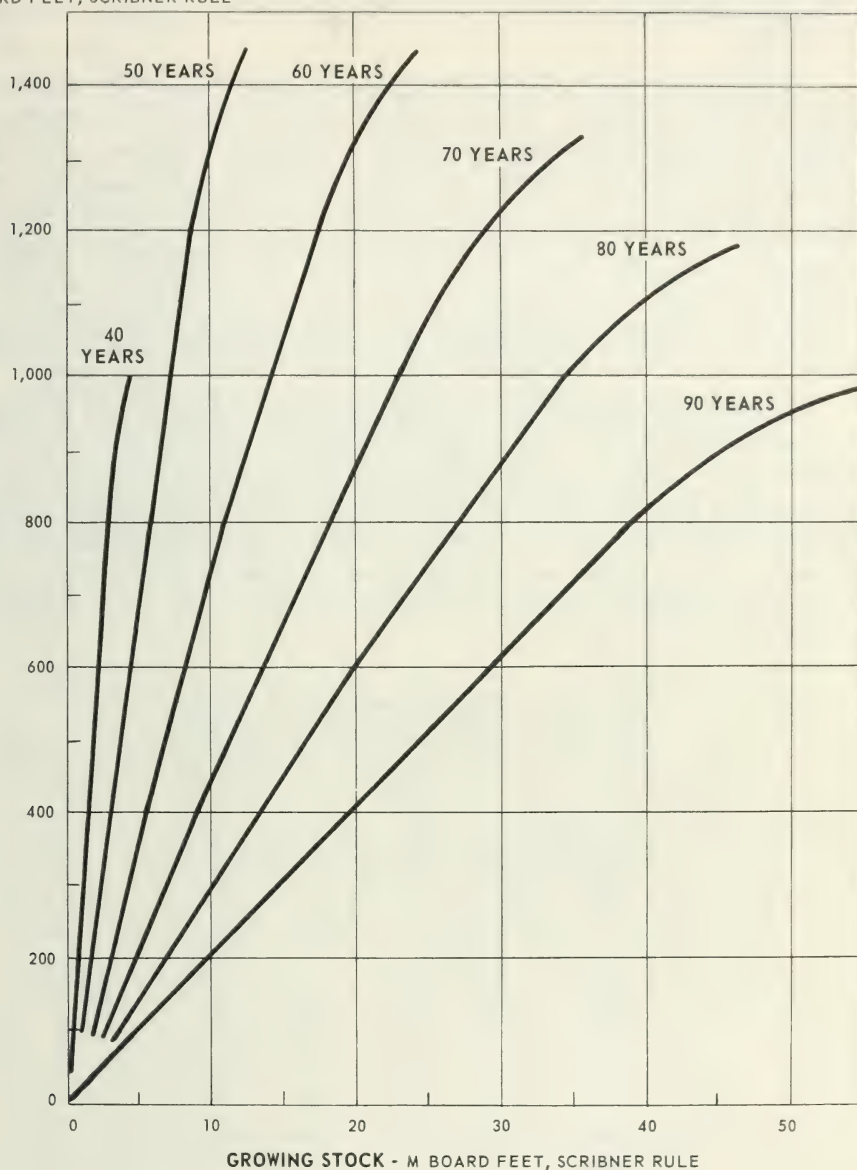


Figure 8.—Estimated current annual gross growth per acre in relation to stand age and growing stock, site III Douglas-fir managed under a thinning regime.

the positions along this curve and all the others in figure 8 are intended to represent longrun alternatives, any one of which may be attained by the forest owner if he plans ahead from the start of the rotation and carries out his thinning regime accordingly.

Rates of return from intensive management.—From an inspection of figure 8 it becomes obvious that the longrun alternatives there represented are not equally fruitful. Take again the 60-year curve as an example. Readings at 1,000-foot intervals of stocking from 14,000 to 24,000 are detailed in table 13, columns 1 and 3. By planning for a 15,000- rather than a 14,000-board foot stocking, the forest owner can get 68 board feet more annual growth (col. 4). This extra growth, expressed in proportion to the extra growing stock (col. 2) required to produce it, constitutes a return of 6.8 percent (col. 5). But at higher levels of stocking, the reward from increasing the growing stock is continually less, falling to 2 percent in the interval between 23,000 and 24,000 board feet of growing stock.

One may well suppose that the forest owner whose guiding rate of interest is 3 percent will not wish to carry more than about 21,000 board feet of growing stock per acre in 60-year stands of Douglas-fir on site III under a thinning regime. If his guiding rate were 6 percent, about 17,000 feet would be his limit. And if his guiding rate were above 7 percent, he would not want to grow his timber to 60 years of age at all, but would confine himself to a shorter rotation during which it would be possible, by thinning, to keep the stand growing at a rate satisfactory to him.

Table 13. — Rate of return on extra growing stock as related to stocking in a thinned 60-year-old, 1-acre stand of Douglas-fir on site III

Growing stock		Current annual growth		Return on extra grow- ing stock
Total	Extra	Total	Extra	
(1)	(2)	(3)	(4)	(5)
Board feet		Percent		
14,000	--	972	--	--
15,000	1,000	1,040	68	6.8
16,000	1,000	1,107	67	6.7
17,000	1,000	1,173	66	6.6
18,000	1,000	1,232	59	5.9
19,000	1,000	1,284	52	5.2
20,000	1,000	1,328	44	4.4
21,000	1,000	1,365	37	3.7
22,000	1,000	1,395	30	3.0
23,000	1,000	1,420	25	2.5
24,000	1,000	1,440	20	2.0

Likewise, by locating the 3-percent points on the successive curves in figure 8, one can trace out a thinning regime for conservative forest owners. The result is the series analyzed in table 14, which is set up after the general pattern and reasoning of table 3.

Economical rotation and output.—Table 14 analyzes a series of stands from 30 to 90 years of age, at 10-year intervals (col. 1). Columns 2 and 6 are read from the growth curves illustrated in figure 8 at normal stocking for young stands where the growth rate is very high, at the 3-percent point for older stands up through 80 years, and at the approximate edge of the plateau for the 90-year stand, which is added, even though its growth rate fails to reach 3 percent, in order to extend the data a bit further for the later purpose of curve drawing. The indicated thinning regime maintains approximately normal stocking to age 50 and gradually reduces normality thereafter to around 75 percent at the end of the rotation.

Columns 3, 4, and 5 in table 14 are the counterpart of columns 6, 7, and 8 in table 3. However, the board-foot unit of measure is retained in table 14.

Column 7 shows the amount of the decadal growth per acre that is not needed as growing stock and can be taken in thinning. Thus the first entry in the column, 1,090 board feet, is derived by subtracting the difference between 4,500 and 300 (col. 1) from 5,290 (col. 6).

Table 14. — Rate of return on extra growing stock as related to average annual timber yield per acre of seven hypothetical regulated Douglas-fir forests on site III managed under a thinning regime at a guiding interest rate of 3 percent

Rotation (years)	Growing stock				Growth per decade			Yield		Return on extra grow- ing stock (11)
	Cumulative		Per acre		Growth per decade		Cumulative (8)	Annual per acre		
	Oldest acre (2)	All acres (3)	Total (4)	Extra (5)	Gross (6)	Cut (7)		Total (9)	Extra (10)	
(1)	Bd. ft.	M bd. ft.								
30	300	1.5	50	--	--	--	300	10	--	--
40	4,500	25.5	638	588	5,290	1,090	5,590	140	130	22.1
50	12,400	110.0	2,200	1,562	9,950	2,050	15,540	311	171	10.9
60	21,100	277.5	4,625	2,425	14,360	5,660	29,900	498	187	7.7
70	28,400	525.0	7,500	2,875	13,710	6,410	43,610	623	125	4.3
80	33,400	834.0	10,425	2,925	11,920	6,920	55,530	694	71	2.4
90	36,800	1,185.0	13,167	2,742	9,050	5,650	64,580	718	24	.9

Column 8, the counterpart of column 2 in table 3, records the yield that would be available from a final harvest cut at the stand age in question plus all intermediate cuts at younger ages. This yield is expressed per acre of the entire forest in column 9, the counterpart of columns 3 and 4 in table 3.

Columns 10 and 11 match columns 5 and 9, respectively, in table 3. When the 1-percent allowance for conversion and regeneration costs is added to the return percentages in column 11 and the result is curved with age and with yield, a rotation of close to 80 years is indicated with an average annual yield from intermediate and harvest cuts of about 680 board feet per acre. Somewhat more than 40 percent of the total yield is from the thinnings, and less than 60 percent is from the final harvest. Growth rate of individual trees is maintained at no fewer than about 6 rings per inch. The breast-high diameter of crop trees at the end of the rotation is in the neighborhood of 22 to 24 inches.

In addition to the yield of saw logs in board feet, the regime of management will produce a volume of smaller diameter wood from young trees removed in thinnings and from the tops of sawtimber trees. Analysis of stand tables provides the estimate that the yield of such material will average 20 cubic feet per acre per year.

The foregoing yields of 680 board feet and 20 additional cubic feet may be regarded as gross, in the sense that they are estimated from plot data. Experience usually shows that the per acre yields obtainable on plots can never quite be reached on whole forest properties. A reduction allowance is needed for blank spots, errors in silvicultural judgment, and unaccounted losses. Furthermore, in the present analysis it is desired to allow for losses in yield arising from the inevitable presence of hardwoods, even in forests managed for conifers, and for the element of uncertainty. Accordingly, the estimated gross yields are cut back 15 percent to net amounts of 578 board feet and 17 additional cubic feet per acre per year. These net yields are judged to represent the reasonable potentialities of timber management on conservatively held site III forest properties in the long run, under the assumptions here being followed.

Yields Under All Classes of Ownership

The same analysis that has just been outlined was made for each of the three classes of forest owners, each of the two product objectives, and each of the four conifer type-site classes. The result is given in table 15. For conservative and intermediate owners, net yields are derived from the gross by applying a reduction factor of 15 percent. However, for the exploitive owner, in order to make some allowance for greater uncertainties, especially those associated with regeneration, a 20-percent cutback is taken.

Table 15. — Estimated forest rotation and annual per acre yield under a thinning regime, by owner class, product objective, and forest type-site class

CONSERVATIVE OWNER								
Forest type-site class	Saw log objective					Wood objective		
	Rotation	Yield per acre						
		Gross		Net				
		Saw logs	Other wood	Saw logs	Other wood	Rotation	Yield per acre	
							Gross	Net
	Years	Bd. ft.	Cu. ft.	Bd. ft.	Cu. ft.	Years	— — —	Cu. ft. — — —
1	70	980	25	833	21	45	225	191
2	80	680	20	578	17	50	180	153
3	90	350	15	298	13	60	120	102
4	95	250	15	212	13	60	100	85
INTERMEDIATE OWNER								
1	55	790	25	672	21	40	190	162
2	60	470	20	400	17	45	155	132
3	75	250	15	212	13	50	100	85
4	80	190	15	162	13	50	80	68
EXPLOITIVE OWNER								
1	45	530	20	424	16	30	150	120
2	50	280	15	224	12	35	115	92
3	55	130	10	104	8	35	65	52
4	60	90	10	72	8	35	55	44

Rotations and per acre yields.—In table 15, one finds rotations ranging from 30 to 95 years. The longer rotations are those for the more conservative owners and the poorer sites. Also, under a saw log objective the rotation is markedly longer than under a wood objective. As compared with rotations indicated for a one-cut program of management, all these rotations are lengthened by the assumption that intermediate cutting will be done. For example, the 80-, 60-, and 50-year saw log rotations for the three classes of owners of type-site 2 are to be compared with rotations of about 70, 55, and 40 years, respectively, indicated for the same owners in table 3, where a one-cut program is assumed. (Here rotations are estimated in the table after adding the 1-percent conversion- and regeneration-cost allowance to the figures in column 9.)

It is important to make clear the spirit in which rotation ages are set forth here and elsewhere in this report and the use visualized for rotation age in forest management. A rotation age is not seen as a fixed or an absolute determinant of harvest time. It is not even seen in practice as the principal guide to the time of harvest. A manager's decision to cut a stand is conceived as resting on con-

siderations of timber value-growth rate, nontimber forest values, alternative opportunities for the use of capital, the changing timber requirements of the plant or market, and the like. Thus, in practice rotation age is believed to be a flexible tool of management. In this report it is used as an analytical device—an index of timber management intensity. The forest rotation is intended to indicate the consequences of management more than the form of it, just as the perfectly regulated forest serves as a basis for reasoning rather than a representation of the form of the real forest.

The yields of table 15 show a very wide range. Gross yields extend from about 100 to nearly 1000 board feet and from 2/3 to more than 2-1/2 cords per acre per year. The higher the site and the lower the guiding interest rate, the greater the yield. Calculations for type-site 4, mostly the upper slopes, are based on the assumption that these forests will grow approximately like Douglas-fir on site 100. The resulting rotations may not be far off, but the yields undoubtedly are conservative, especially in view of the assumption that noble or red fir will be favored on these lands. This element of conservatism has been retained in the estimates to provide an allowance for the many uncertainties regarding the management of the upper slopes.

Forest acreage.—The next step in this analysis of longrun timber yields is to estimate the forest acreages to which the per acre yields of table 15 apply. For this purpose, table 12 provides a starting point. Beginning with that table, it is necessary to estimate the conifer sites of the lands shown in previous tables as bearing a hardwood cover (type-site 5) and to allocate the hardwood acreages to the other four type-sites. Such allocation is required because of lack of satisfactory hardwood yield data. In this manner, hardwood growth is allowed for in the calculation of longrun yield. A basis for the allocation is the site records of the Forest Survey and the forest site maps of the subregion. These, supplemented by some general judgment, produce the result shown in table 16.

Table 16. — Estimated commercial forest land acreage in the Douglas-fir subregion in the long run, by district, owner class, and conifer type-site class
(In thousand acres)

ENTIRE SUBREGION							
Conifer type-site class	Private holdings			Public holdings			All holdings
	Large	Medium	Small	National Forest	Other Federal	Other	
1	4,778	221	787	1,229	851	1,042	8,908
2	3,177	319	1,281	1,823	962	699	8,261
3	818	225	1,040	2,499	597	376	5,555
4	86	46	39	1,770	66	96	2,103
All	8,859	811	3,147	7,321	2,476	2,213	24,827
PUGET SOUND DISTRICT							
1	1,316	105	173	156	16	317	2,083
2	1,095	117	475	412	58	304	2,461
3	352	127	432	622	58	288	1,879
4	34	12	13	585	15	94	753
All	2,797	361	1,093	1,775	147	1,003	7,176
COLUMBIA RIVER DISTRICT							
1	2,409	84	507	900	251	667	4,818
2	1,281	163	667	935	327	329	3,702
3	155	89	326	907	246	87	1,810
4	50	12	24	666	22	2	776
All	3,895	348	1,524	3,408	846	1,085	11,106
SOUTHWEST OREGON DISTRICT							
1	1,053	32	107	173	584	58	2,007
2	801	39	139	476	577	66	2,098
3	311	9	282	970	293	1	1,866
4	2	22	2	519	29	--	574
All	2,167	102	530	2,138	1,483	125	6,547

It is evident from table 16 that a great share of the productive potential of the Douglas-fir subregion lies in the Columbia River district. Not only is this district the largest of the three, but it contains proportionally more higher site lands and less of the lower sites than the other districts.

For the acreage data of table 16 to be usable, its forest-ownership classification must be translated into the classification of table 15; conservative, intermediate, and exploitive owners. It is assumed that in the long run, the translation may be made on the basis of the following percentages:

	Conservative	Intermediate	Exploitive
Large private	85	15	0
Medium private	20	70	10
Small Private			
Farm	10	20	70
Nonfarm	20	50	30
Average	10	30	60
National Forest	100	0	0
Other Federal	85	15	0
Other public	60	40	0

The result of the translation, for the Douglas-fir subregion as a whole, is given in table 17. The table allocates 75 percent of the entire commercial forest acreage to conservative ownership, 17 percent to intermediate, and 8 percent to exploitive ownership.

Table 17. — Estimated commercial forest land acreage in the Douglas-fir subregion in the long run, by owner class and conifer type-site class

Conifer type-site class	Conservative owners	Intermediate owners	Exploitive owners	All owners
----- Thousand acres -----				
1	6,761	1,653	494	8,908
2	5,952	1,508	801	8,261
3	4,076	833	646	5,555
4	1,971	104	28	2,103
All	18,760	4,098	1,969	24,827

Total yields.—Total potential timber output of the Douglas-fir subregion in the long run may now be estimated by multiplying the acreages of table 17 by the yields of table 15. The estimates are shown in table 18. They add to 13.1 billion board feet and 0.4 billion additional cubic feet per year under a saw log objective, or 3.5 billion cubic feet per year under a wood objective. The average per acre yields represented by these amounts are 526 board feet and 17 additional cubic feet, and 141 cubic feet (about 1-2/3 cords). The total saw log yield of 13.1 billion board feet is about 7 percent above the subregion's average annual timber output during the decade of the 1950's. More than half of the total potential saw log yield is attributed to type-site 1. More than four-fifths is attributed to conservative owners.

The potential longrun yield of 13.1 billion board feet is shown again in table 19, where it is allocated to the six classes of forest ownership used throughout most of this report. A little more than half of the potential is on private holdings, mostly the big holdings. About a fourth of it is on the National Forests. Currently, a little more than a fourth of the cut is from National Forests.

Some further interpretation of the longrun potential yield estimates of tables 18 and 19 will be offered toward the close of chapter 3.

Table 18. — Estimated total potential timber output per year from the Douglas-fir subregion in the long run, by product objective, owner class, and conifer type-site class

SAW LOG OBJECTIVE: SAW LOG YIELD				
Conifer type-site class	Conservative owners	Intermediate owners	Exploitive owners	All owners
----- Million board feet -----				
1	5,632	1,111	209	6,952
2	3,440	603	179	4,222
3	1,215	177	67	1,459
4	418	17	2	437
All	10,705	1,908	457	13,070
SAW LOG OBJECTIVE: YIELD OF OTHER WOOD				
----- Million cubic feet -----				
1	142.0	34.7	7.9	184.6
2	101.2	25.6	9.6	136.4
3	53.0	10.8	5.2	69.0
4	25.6	1.4	.2	27.2
All	321.8	72.5	22.9	417.2
WOOD OBJECTIVE: TOTAL YIELD				
----- Million cubic feet -----				
1	1,291.4	267.8	59.3	1,618.5
2	910.7	199.1	73.7	1,183.5
3	415.8	70.8	33.6	520.2
4	167.5	7.1	1.2	175.8
All	2,785.4	544.8	167.8	3,498.0

Table 19. — Estimated total potential sawtimber output per year from the Douglas-fir subregion in the long run, by owner class and conifer type-site class

Conifer type- site class	Private holdings			Public holdings			All hold- ings	Per acre average
	Large	Medium	Small	National Forest	Other Federal	Other		
	----- Million board feet -----							Board feet
1	3,864	150	425	1,024	688	801	6,952	780
2	1,751	133	399	1,054	531	354	4,222	511
3	233	50	162	745	170	99	1,459	263
4	18	7	5	375	14	18	437	208
All	5,866	340	991	3,198	1,403	1,272	13,070	526

Yields Under Alternative Assumptions

It is now possible to test the effect of alternative assumptions upon the long-run potential output. Tests will be made of the effect of (1) stumpage price, (2) interest rate, and (3) land management and use. The output data expressed in board feet (Scribner rule) and applying to a saw log objective will be used in these tests. The board foot data are chosen because they are more familiar and more readily interpretable. Major findings of the analysis will be generally applicable also to cubic foot yields.

Stumpage price.—From the review of the influences upon timber output in chapter 2, it appears that the prospective stumpage-price level (in relation to costs) may be expected to have an effect upon longrun timber yields through its influence upon certain types of management decisions, notably those in reference to land use, forest regeneration, and the use of fertilizer.

Estimates of the longrun response of timber output to price-level prospects ranging upward from \$40 (1957-59 basis) per thousand board feet may be derived from the relationships developed in chapter 2, together with acreage and yield data from the present chapter. Thus, for example, with a price prospect of \$100, the following extra annual yields may be possible in the long run beyond the 13.1 billion board feet judged to be obtainable with a \$40 prospect: (1) from 750,000 acres of land formerly in farms, assuming an average yield of 400 board feet per acre per year, 0.3 billion feet; (2) from extra regeneration efforts of exploitive forest owners (fig. 6) on 1,969,000 acres, an average of 14.7 board feet per acre or about 29 million feet annually altogether; (3) from fertilizer programs of conservative owners on all sites (table 6), an average of 91.5 board feet per acre on 18,518,000 acres or 1,694 million board feet per year in total. These extra annual yields add to about 2.0 billion feet and make a total annual yield of 15.1 billion feet with the \$100 price prospect.

With longrun prospective prices below \$40, lower yields could be looked for, mainly because intermediate cutting would be discouraged. But the yields would still be substantial. Take a hypothetical case: even if anticipated price approached zero, such lands as remained in forest use would, under the protection program assumed, be free to grow timber. And the timber could be harvested from time to time. It is estimated that the region could produce all of 5 billion feet per year under these circumstances.

The foregoing estimates are expressed, in the upper part of figure 9, as a curve of longrun annual timber output over prospective stumpage-price level. Price, within the range considered, is seen to have but a small bearing upon the calculated output; and the higher the price, the smaller the bearing. What this upper curve in figure 9 would say is that it is not possible for consumers to get much more timber grown by offering to pay more for it—nor, within limits, will they sacrifice much timber by offering to pay less. This is because in the last analysis it takes growing stock to make growth. And, as brought out in chapter 2, the price level has negligible bearing upon the holding of growing stock by forest owners.

Interest rate.—The output-price relationship illustrated in the upper part of figure 9 is conceived to hold true when other things are equal—that is, when costs remain unchanged at the levels assumed. For example, interest rates are conceived to remain at the 3-, 6-, and 12-percent levels for the three major classes of forest owners, and the weighted average interest rate for all owners is 4 percent. At a higher guiding rate of interest, the output-price curve would lie below the one drawn. At a guiding rate lower than 4 percent, the curve would lie above the present one.

ANNUAL TIMBER OUTPUT

BILLION BOARD FEET, SCRIBNER RULE

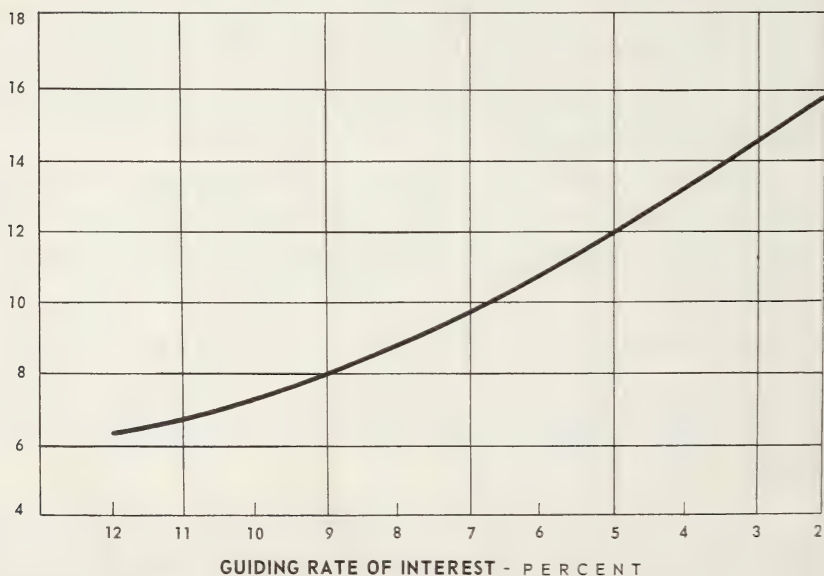
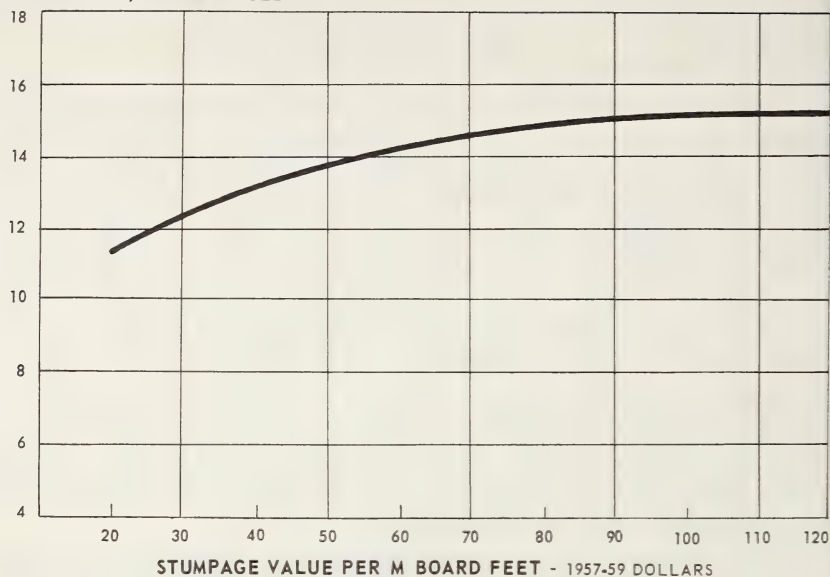


Figure 9.—Longrun potential annual timber output of the Douglas-fir subregion, in relation to stumpage value and to the guiding rate of interest.

The general relationship between longrun output and the guiding rate of interest is graphed in the lower part of figure 9. Here again, other things are conceived to be held the same. The prospective stumpage-price level is held at \$40. The lower curve, like the upper one, is derived from five plotted points: At 4 percent, output is 13.1 billion board feet, as determined in table 18; at 3, 6, and 12 percent, outputs are found by multiplying the estimated total commercial forest acreage (considering the influence of interest rate upon land use) by the appropriate per acre output from table 15; at 2 percent, output is estimated by analogous procedure with additional allowance for fertilizer and improved regeneration programs, which begin to show a profit even at the \$40 price level.

Since the guiding rate of interest works upon potential output through all the same influences as does price and since it exerts an additional effect through its control over growing stock and rotation length, it is not surprising to find that output, especially in the upper range, is considerably more sensitive to the rate of interest than to the price level. Indeed, it appears from figure 9 that larger output gains may be forthcoming from each successive lowering of the interest rate. At rates approaching zero, timber yields presumably approach the biological maximum attainable under an extremely intensive cultural regime.

Land management and use.—Finally, three alternative assumptions will be tested in their effects upon longrun potential yield: (1) the assumption that on exploitively held forest lands, all special timber production efforts except forest protection will be abandoned; (2) the assumption that an additional million acres of National Forest lands will be reserved as vast recreational areas; (3) the assumption that this million acres will not be reserved and that a further million acres classed in the principal assumption as reserved will instead be available primarily for timber growing.

The small privately owned forest holdings have often been characterized as the crux of the forestry problem in the United States, referring to the fact that these holdings make up a large share of all the forest land, are for the most part exploitively managed, and are difficult to reach through forestry programs. In the Douglas-fir subregion, small holdings are nearly a fourth of all the commercial forest and consequently an object of interest.

The question of how much timber may be grown economically on the small holdings in Douglas-fir country has been explored. The longrun potentialities envisaged for them were, first, that nearly half of their acreage might be absorbed into larger holdings and thus come under conservative regimes of management and, second, that the remainder might be handled under the most intensive programs consistent with their owners' guiding rates of interest. Such programs may be thought of as requiring a good deal of extension effort on the part of public agencies and perhaps also wood-using industry—effort in the form of technical advice and assistance. By way of contrast, it may be well to estimate longrun timber-output potentialities in the absence of extension programs and in the absence of any special timber-management measures other than forest protection.

Since the question at issue here concerns not so much the small holdings as the properties in exploitive ownership (the counterpart of today's "crux of the

forest problem"), attention will be directed to the 2 million acres of commercial forest land assumed to remain in such ownership in the long run.

The potential annual output of the exploitively held properties in the absence of special effort (and with a price prospect of \$40 per thousand) is estimated to be 160 million board feet, as against 457 million with the special effort (table 18). That is to say, the result of the effort might be, at most, about 300 million board feet of additional annual yield in the long run. Or, to look at the matter from the other viewpoint, the longrun loss in annual yield from a writeoff of the exploitively held forest properties might be as much as 300 million board feet, or 2-1/4 percent of the total. It is largely in the public values of this 300 million feet of timber that justification would ultimately be sought for public forestry programs directed at the exploitive owners.

As for the alternative assumptions about vast recreational areas—(a) that an extra million acres of forest will be reserved, and (b) that an extra million acres will be opened to timber management—the lands involved would be largely the poorer sites at the higher elevations. Indeed, it is assumed that in terms of the conifer type-sites, either of the million-acre aggregates would consist of 60-percent type-site 4 and the remainder type-sites 2 and 3, mostly the latter. With these acreage assumptions and the per acre yields of table 15, one may calculate that the loss of a million acres from the timber column, or the gain of a million acres, would in the long run amount to about 270 million board feet of output per year, or 2 percent of the total.

What the Findings Imply

Although the long run as conceived in this study is a remote period, the interest of the region in this period is not remote but immediate, because the shape of things in the long run is being determined today by today's planning. It is a result of the long production span in forestry that major questions of the far future must be answered now. The questions of landownership in the long run, of land use, and most particularly of timber types, rotations, and output are current and live questions—policy issues of today and not of some vague tomorrow.

Consequently, it is of great and immediate interest to search out some of the implications of the longrun timber-output relationships developed in this study.

Problem of altering output.—The relationships important to analyze are those between output on the one hand and its major determinants on the other. These are the vital relationships because they must come into play in any effort by the community (that is, the industry, the State, or the Nation) to alter the supply outlook, either by deliberate measures or through the automatic devices of the economy.

What is involved in altering the supply outlook? Though 13.1 billion board feet is estimated to be an economic longrun level of timber yield under the principal assumptions of this study, higher figures may be considered by the community and, moreover, proposed as a goal. What is involved in reaching such a goal?

To raise timber output in the long run will involve a cost to the community. That is to say, it will mean a cost to the forest owner—a cost of forgoing returns (presumably at the guiding rate) from alternative investment-or-spending in favor of relatively low returns from the additional timber inventory needed to raise output. This cost is, in effect, a carrying charge or storage charge on the extra growing stock required to raise output. Forest owners will need to have in view a repayment from some source if they are to bear such a charge, for the amount may be considerable.

Approaching output through price.—What constitutes an effective method for raising timber output? For example, in the foregoing illustration, how could the community pay private forest owners an extra \$500 million per year so as to obtain from these owners the additional production that \$500 million would defray? Clearly, the community could not do it by spending the money in the forest products market. For if this should be attempted—that is, if demands for timber should rise—the probable outcome would be simply a much higher price for timber but very little more production of it, as the upper curve in figure 9 suggests. The extra \$500 million, if it could be spent at all in the market, would merely be pocketed by those forest owners who were growing and cutting timber anyhow. Ultimately, the money would show up largely in profits from the holding of timberland and in increments in the value of such land. If owners foresaw that timber prices would stay at the new, high level, they would logically plan to cut about as much timber as before. Or, if the price rise should lead to anticipation of further increases, owners might well decide to cut less timber so as to accumulate some stocks and enhance their revenues later on. Thus the community would achieve just the opposite of what it intended with its cash outlays.

It is sometimes said that the law of supply and demand is the best for-ester, but surely this is to give the law undeserved credit. Through the price of the product, the law does indeed work to get more pulp and paper made, more lumber cut, and even more timber harvested. But when it comes to getting more wood grown, the law of supply and demand promises to be but an indifferent ally. Again, the cause of this is that the amount of wood grown depends greatly on the amount of growing stock held, and the latter depends very little on wood value, which for the forest owner is both a source of revenue and a countervailing source of cost.

Considering that high timber prices represent mainly a penalty for the wood-consuming community, and that continuously rising prices, though a stimulus to longrun output, entail costs out of all proportion to their benefits, there is much to be said in favor of stable, moderate prices such as have been assumed for the future in this report. Such a price scheme is most favorable to abundant timber consumption and can easily be compatible with abundant production. A community policy of holding timber prices down can be made effective in two general ways.

First, prices will be held down through efforts to increase timber output in the short run. The principal way to accomplish this without jeopardizing longrun

production is by an accelerated program of old-growth conversion and replacement by thrifty young-growth forests, which would mean primarily an increased cutting schedule for the public forests. Accomplishing such a program is a problem of the transition period.

Second, timber prices will be held down if the output of timber rises in the long run in response to nonprice influences. The principal such influence for the discussion of which this report has laid a foundation—and apparently the principal influence through which low-cost programs may work to raise production—is the forest owner's guiding rate of interest. The problem is to lower the guiding rates under which the commercial forest lands of the region are managed.

Approaching output through interest rates.—One way that guiding rates of interest are reduced is through transfers of forest properties from high rate owners to lower rate owners. It is assumed in this report that such transfers will proceed in the future through the initiative of the lower rate, stronger private owners. The assumed trends in ownership represent a gain in longrun timber-output potential and a loss in breadth of the private-land ownership base as the holding of land becomes concentrated in fewer hands. Such gains and losses from concentration are the factors that the community can weigh in order to determine its policy respecting forest ownership trends.

If the community proposes either to acknowledge or to promote the trend toward concentration in private forest ownership, then it has open to it various steps in extension education and in research which may make for more orderly and equitable land transfers. One of the most obvious of these steps concerns the land market, where the forces at work are concentrated. It consists of discovering and encouraging the adoption of procedures whereby the market can measure and reflect all the values in timberland, especially the value of slow-pay-out investments, as in the planting and early care of the forest stand. Thereby the forest owner may be encouraged to go ahead with such investments even if the permanence of his tenure is much in doubt.

Besides changes in ownership, the other way that guiding rates of interest are reduced is through a rate-reduction trend for individual owners or classes of owners. The analysis of determinants of the guiding rate provides a checklist of the conditions under which a forest owner's rate may be reduced:

1. A maturing of the economy and consequent decline in the prospective rate of return from alternative investments.

2. A rise in the real incomes of the forest owners whose guiding rates are determined by consumption alternatives. The owners in question here are primarily the farm woodland owners. Any agricultural policy that favors the retirement of marginal farms and the development and consolidation of productive commercial farms will promote timber conservation and high outputs in the long run.

3. The institution of public controls or subsidies to intensify the timber-management practices of forest owners in the exploitive and intermediate groups.

4. Measures to raise fringe benefits and transfer costs of forestry investments. Public policies that foster the use of net income taxation in preference to other forms of taxation for raising public revenues will tend to promote intensive timber management on private lands.

5. Measures to reduce the risks of timber management. Risks associated with forest property taxation—the threat of higher rates or of disadvantageous changes in the terms of taxation—may be important here. Early adoption of neutral methods of taxation will help to reduce risk. Also helpful will be research and action programs that will reduce prospective timber losses from insects, disease, and fire.

All such measures may, of course, cost something. And inevitably there is a critical level of output beyond which the opportunity costs will exceed the rewards. The alternatives to pushing beyond the longrun critical level of timber output in the Douglas-fir subregion include getting more wood from other parts of the United States up to their own critical levels of output, importing more wood and wood products, and using more substitutes for wood.

Chapter 4

Timber Yields During Transition

The report has been concerned up to this point largely with the timber yields of the long run. An economic potential output of some 13.1 billion board feet and 400 million additional cubic feet per year has been worked out for the Douglas-fir subregion under assumed conditions of land use and forest management. The forces that control the longrun potential have been studied, and some measures that might change longrun output have been inferred. Generally, the guiding rate of interest appears to be highly influential in timber production, while timber prices have comparatively little effect.

The longrun potential is in the nature of a destination or target. Since the long run is distant, some may view the target with detachment or unconcern. But when it comes to the means and the route for reaching the longrun level of production, that is a different matter, of obviously immense and immediate interest to everyone who has a stake in the Douglas-fir industry. The report turns now to this vital matter of the transition period—the period of conversion to a young-growth economy.

Three principal questions are involved:

1. What are the current forest acreage and timber volume in the Douglas-fir subregion and how are the prospects for the transition period affected by their current distribution among districts, forest type sites, classes of ownership, and, most especially, stand-age classes?
2. If present trends in forest management and timber cutting should continue, what changes would be most likely to occur in timber output and growing stock during the transition period in the Douglas-fir subregion, and what problems might result?
3. What are the possibilities, if forest management were intensified faster than present trends suggest and if the subregion's old-growth timber were converted to young growth more rapidly than is now intended, and what problems are likely to arise during such an accelerated transition?

The analysis aimed at the foregoing questions will be built around a sawtimber-management objective, including a sawtimber rotation, and not a wood-fiber objective and rotation. It will use as its principal unit of timber measurement the board foot (net Scribner scale) rather than the cubic foot. Since the analysis concerns the immediate and near future, this conformity with today's viewpoint and conventions is believed to be appropriate.

Current Forest Inventory

For the purpose of looking at current forest conditions and their bearing upon the transition, reference will be made again to the basic inventory prepared for

this study and already introduced in tables 1, 2, and 8. The inventory is tabulated in detail in Appendix A, where also the compilation procedure is explained. The period to which the data refers is the "decade of 1950's." For convenience, the date of reference will be interpreted here to be the end of the decade and the figures cited in the present tense.

Since the time of this analysis, additional inventories have been made; however, preliminary new totals as of this publication are basically in agreement with the figures shown in this report.

Growing stock.—The subregion's 25-3/4 million acres of commercial forest land support some 647 billion board feet of sawtimber, an average of about 25,000 board feet per acre. It is interesting to compare this current growing stock, which supports an annual growth of roughly 5 billion board feet and an annual cut of about 11.5 billion, with the growing stock estimated to be required for producing the subregional annual yield of 13.1 billion board feet in the long run. Under the specified management assumptions, the longrun estimate of required growing stock is 203 billion board feet, or an average of 8,200 board feet per acre. That is to say, the estimated growing stock for the long run in the Douglas-fir subregion is 31 percent of today's growing stock. Approximately the same proportion holds for each of the subregion's three districts. The comparable percentages for the four conifer type-sites are:

	<u>Required growing stock</u> <u>in percent of actual</u>
Type-site 1	41
Type-site 2	36
Type-site 3	18
Type-site 4	11

The degree of excess growing stock increases as one moves from the better to the poorer sites (i.e., from lower to higher elevations and from easier to more difficult terrain), largely because this is the general order in which the sites have been entered for exploitation and in which conversion to young growth has progressed. Type-sites 3 and 4 include most of the subregion's remaining commercial forest that is poorly supplied with roads.

The excess of growing stock is further described by the age distribution of the subregion's live sawtimber. For this purpose, it is necessary to exclude 53 billion board feet of timber in uneven-aged stands and to turn attention to the remainder of the sawtimber inventory, some 594 billion feet, amounting to more than nine-tenths of the total. This saw-timber in even-aged stands is about equally divided among the four 100-year age classes that reach from 1 to 400 years. If 50-year age classes are considered, again the distribution is roughly equal, save that 51- to 100-year stands account for much more than their proportionate share of the sawtimber, while 1- to 50-year stands contain much less. The whole distribution of live, even-aged sawtimber by age class is laid out in figure 10, where it is represented by the crosshatched cluster of bars.

ACTUAL vs. DESIRED GROWING STOCK

GROWING STOCK

BILLION BOARD FEET PER 20-YEAR AGE CLASS

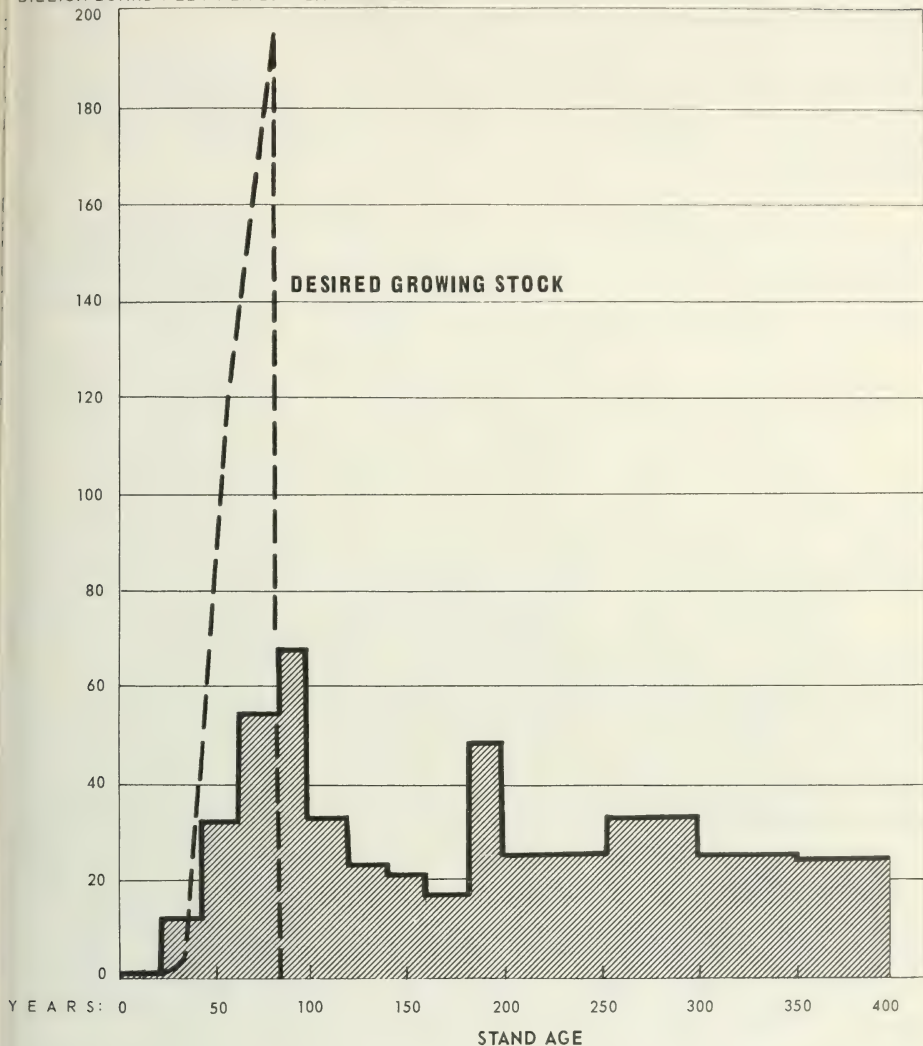


Figure 10.—Sawtimber growing stock by stand-age class in the Douglas-fir sub-region, decade of 1950's.

Suppose, to make the story simple and not exaggerate the excess of growing stock, that the forest were all of medium site (index 140), conservatively held and intensively managed on an indicated sawtimber rotation of 80 years. The potential output of such a forest—i.e., the economic potential—would be in the neighborhood of 17 billion board feet per year. The sawtimber growing stock required to sustain such an output, about 240 billion board feet, is traced by the broken line in figure 10. It is little more than a third of the growing stock being carried today. Thus are pointed up the two great timber-management tasks of the transition period:

1. Pursuing the best program for liquidating the excess growing stock. For illustration of what this task involves for the various owners, note that the 491 billion board feet of timber in excess of 80-year age (see fig. 10) is distributed as follows, in percentage, among classes of ownership:

Private holdings:

Large	27
Medium	4
Small	7

Public Holdings:

National Forest	46
Other Federal	10
Other	6

All holdings 100

2. Packing the required growing stock into the age classes where it is needed. This task is represented in figure 10 by the uncrosshatched portion of the area under the broken line. In practice, it will take the form of getting tree regeneration and carrying out subsequent cultural measures on lands from which overage timber has been removed. Its aim will be to raise the efficiency of the subregion's sawtimber growing stock—today's annual net growth amounts to less than 1 percent of stock; even the cut is but 2 percent of stock; a managed growing stock such as that outlined in figure 10 would yield 6 or 7 percent per year.

The question of how fast to push ahead with the required shifts and changes of the transition—how fast to raise the efficiency of capital by moving to a young-growth economy—is perhaps the principal forestry question in Douglas-fir country today.

Commercial forest acreage.—In some ways more revealing of transition problems than the distribution of growing stock is the distribution of commercial forest land acreage. Acreage is the more permanent feature of the forest, and the ideal age-class distribution of acreage is much simpler to describe than is that of growing stock.

Age-class distributions of commercial forest acreage in the Douglas-fir subregion and its three districts are summarized in figure 11 and detailed in figures 16 through 19 and tables 25-28 Appendix A. Some of the highlights are as follows:

On the 20-1/2 million acres of stocked, even-aged coniferous commercial forest in the subregion, the youngest stands are in general the most extensive and the oldest stands the least. The distribution by 50-year age class is approximately:

<u>Age class (years):</u>	<u>Percent</u>
1-50	39
51-100	22
101-150	8
151-200	8
201-250	7
251-300	7
301-350	5
351 or more	4
All classes	100

The form of this distribution is attributable mainly to the history of cutting and fire, in addition to the natural life span of conifers on the various sites. Most of the forest originated within the past 100 years—in fact, within the past 50—because that is when most of the timber cutting and burning were concentrated.

The prominence of forests that are in the first century of life is a general feature of each of the three districts in the Douglas-fir subregion and of virtually every category of private forest. It is a feature, also, of some of the public categories, especially those other than National Forest—and in the Columbia River district, even of National Forest. That is to say, forest conversion from old growth to young growth is progressing everywhere, but it has progressed farthest on private lands and least far on the National Forests.

As one moves southward from the Puget Sound district, where the concentration of forest acreage in the younger age classes is very pronounced, he finds in general less and less such concentration, and certainly the least in the Southwest Oregon district (fig. 11). He is moving southward over the same route taken by the lumber industry and by the fires that followed lumbering or introduced farming. He is, in effect, observing the influence upon forest structure of the progressively different history illustrated in figure 2 and in figure 4. He is observing the progress of forest conversion from old growth to young growth.

Another aspect of the same history and progress is discovered when one compares the four conifer type-sites, as in figures 16 through 19. He finds everywhere a regular graduation from type-site 1 through type-site 4, with the former showing the greatest concentration in young stands, the latter the least. Generally speaking, type-site 1 has always been the most accessible forest and certainly the most attractive for exploitation and conversion. And type-site 4 has been the least so.

AREA BY AGE CLASS

PERCENT PER 20-YEAR AGE CLASS

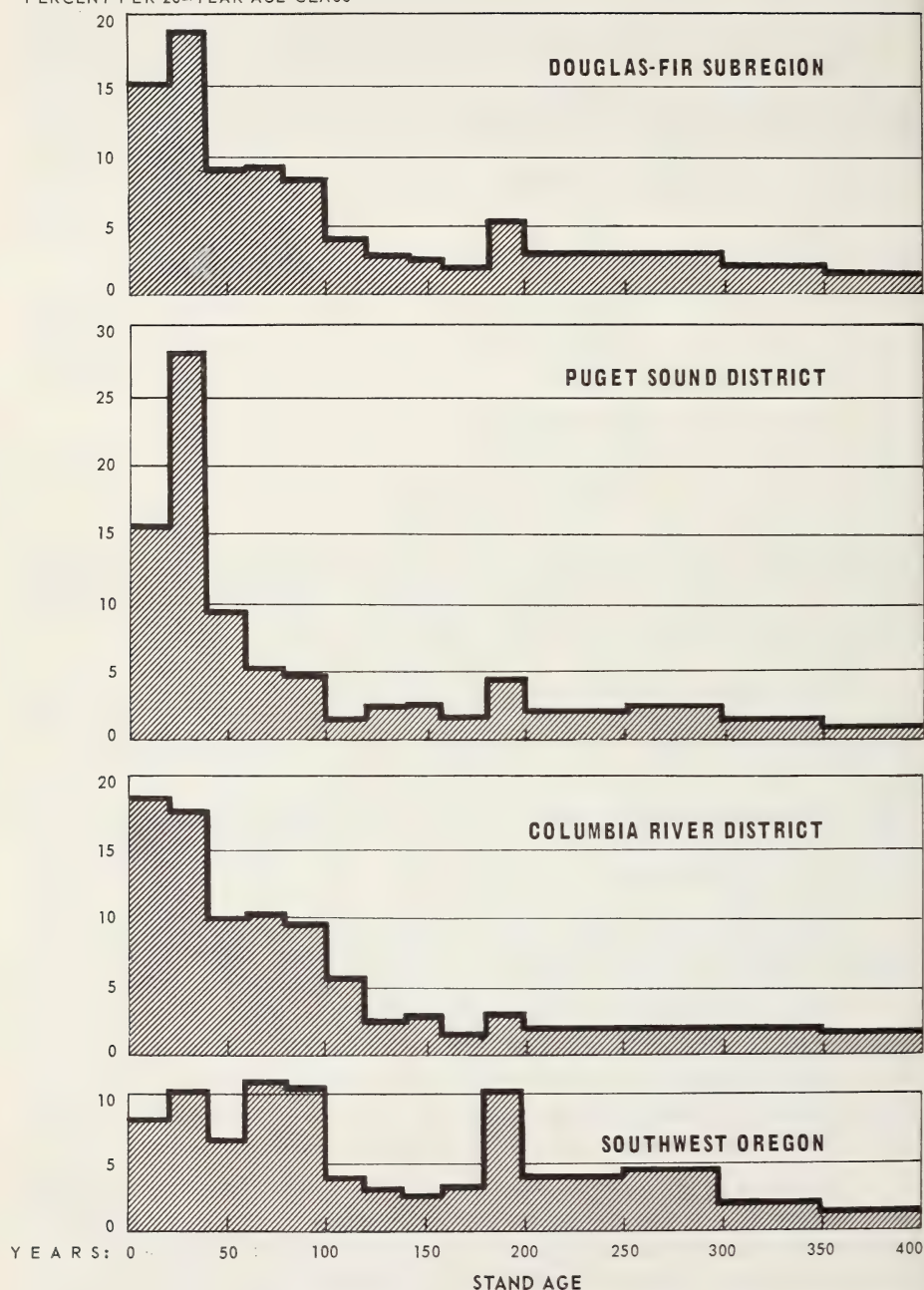


Figure 11.—Distribution of even-aged coniferous commercial forest area by stand-age class, Douglas-fir subregion and its three districts, decade of 1950's.

Within the important age class 1 to 100 years, stands between 1 and 40 years are most prominent; six-tenths of such stands are on private holdings in the Puget Sound and Columbia River districts. Young forests from 21 to 40 years of age are especially extensive. Nearly half of these are in the Puget Sound district. Most of them became established on cutovers, both old and recent, during the 1930's, when a tightening of fire control greatly reduced the burning and reburning of such lands (see fig. 4). Forests in the age class from 1 to 20 years, which is the next most extensive 20-year age class in the Douglas-fir subregion, are somewhat concentrated in the Columbia River district, where the effects of better fire control were felt later than in the district to the north.

Besides the forests in the age classes from 1 to 100 years, the older stands, that range for the most part, up to 400 years, are impressively extensive. There are more than 8 million acres of these older forests in the Douglas-fir subregion. In the Puget Sound and Columbia River districts, they make up a little more than one-third of the total acreage of stocked, even-aged coniferous forests. In the Southwest Oregon district, they are more than one-half of the total. Their prominence is clearly apparent in figure 11. In the same figure, the 181- to 200-year age class is seen to stand out to some extent in all districts and most conspicuously in the Southwest Oregon. The widely occurring forests of this age appear to have originated in the wake of great conflagrations.

Significance of forest inventory.—What is the significance of the timber inventory with respect to the transition era that lies ahead? The inventory stands at the center of certain key issues and questions about the transition, such as whether there is a gap in the age-class distribution that threatens to interrupt or curtail regional timber output, whether such a gap exists for particular forest owners or classes of owners, and how the age-class distribution affects the choice of a conversion period.

The current distributions of forest acreage by stand-age class may be compared with those of ideally regulated forests. For this purpose, it is well to take note of nonstocked forest land acreage in addition to the stocked. This is done in figure 12, where nonstocked acreage is represented by means of a bar, 20 years wide, to the left of the zero-year mark. Such a charting implies that this acreage will be restocked in the course of the next 20 years. Figure 12 excludes forests of type-site 5 in order to focus attention on the comparatively homogenous softwoods. The omission is believed to have negligible effect on the analysis which follows.

If, in figure 12, the same simplifying assumption is made as was used in figure 10—that an average 80-year rotation is to be followed on all lands—then, if the forest were perfectly regulated, 25 percent of its total acreage would fall in each of the four 20-year age classes up to 80 years. This ideal age-class distribution is marked out with broken lines in the upper left graph of figure 12.

It is seen in figure 12 that where there is insufficient forest acreage in stands below rotation age to fill the rectangle representing the ideal and where there

AREA BY AGE CLASS AND OWNER

PERCENT PER 20-YEAR AGE CLASS

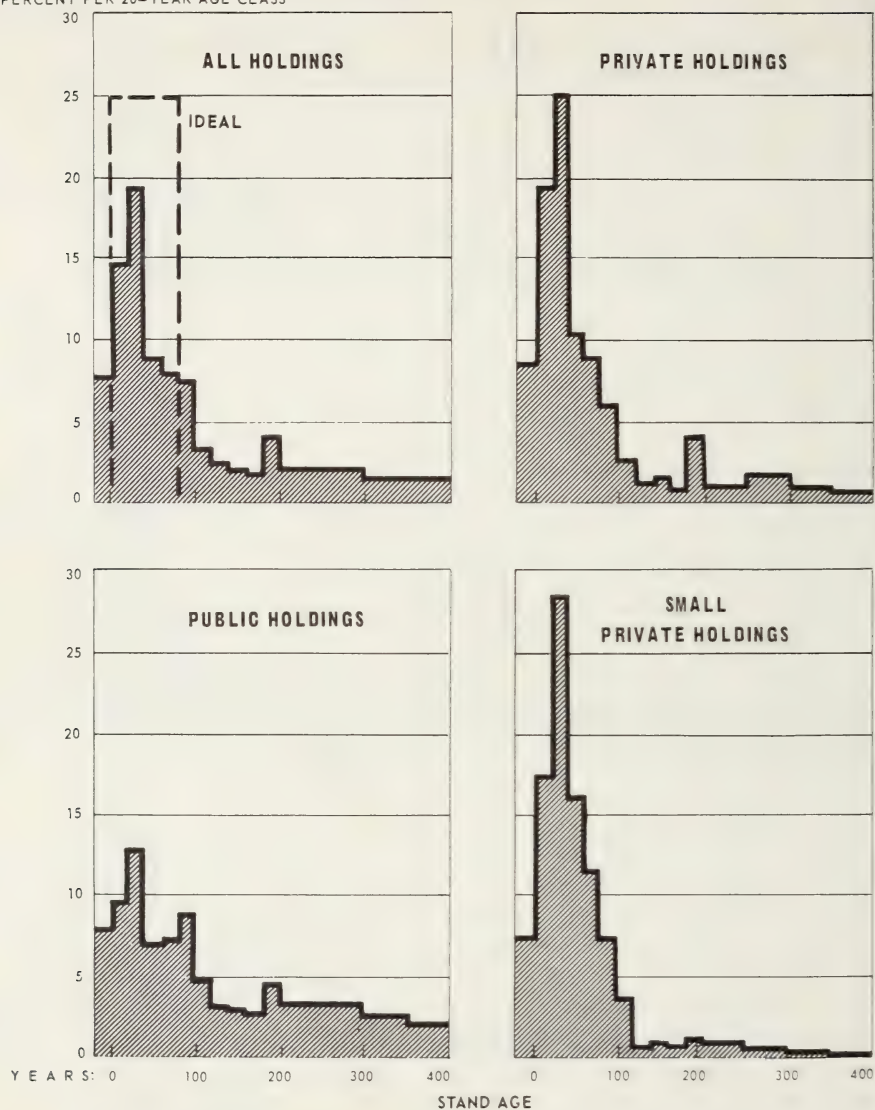


Figure 12.—Distribution of even-aged coniferous commercial forest area by stand-age class on four classes of forest holdings in the Douglas-fir subregion, decade of 1950's.

are at the same time stands above rotation age, the latter can be harvested to make up the insufficiency of the former. Indeed, if there are no nonstocked areas and if none of the age classes under rotation age exceeds its ideal share of total acreage (if no bars project through the top of the rectangle), then the overage areas are just enough to make up the insufficiency. In this case, an ideal age-class distribution can be reached by the end of one rotation. And even during this rotation, there need be no departure from even flow—that is, from generally equal or increasing outputs from period to period of 5 or 10 years or more.

The foregoing propositions are abstract. The ideal distribution of age classes is more a general planning guide than a specific goal for any forest owner or for any community. Even in countries where forests have been under management for generations, few examples of mathematically exact forest regulation are to be seen. In practice, the rotation is a general and flexible idea, and so is age-class arrangement. On any forest property or group of properties, cuts vary from year to year and from decade to decade; the quantity of timber currently reaching rotation age is seldom identical with the current cut; and the discrepancy is remedied by harvesting older or younger stands. However, the ideas of rotation length, age-class distribution, and even flow are still very useful for analyzing the problems of transition in the Douglas-fir subregion.

Even flow of timber.—It appears that the circumstances which may lead to a marked departure from even flow during the transition period are these:

1. An excessively great acreage of forest (much more than its share in the ideal distribution) in an age class of stands younger than rotation age. This situation has developed on some individual forest properties and in some widespread communities after rapid timber cutting or extensive forest burning.

2. An excessively long rotation—one which reduces the ideal percentage of area in any age class to the point where the commonest class becomes overabundant.

It appears in the upper left chart of figure 12 that in the Douglas-fir subregion as a whole, in all classes of ownership combined, there is no threat of reduction in the flow of timber during the period of transition as a result of a gap in age distribution. The same is true of all public holdings as a group and of all private holdings. Small private holdings appear to include an excessive acreage of stands in the 21- to 40-year age class—until it is realized that these holdings will surely be carried on a shorter rotation than 80 years. On medium sites, the average saw log rotation foreseen for small private forest holdings even in the long run amounts to only 56 years, which implies an ideal age-distribution rectangle 56 years wide and 36 percent high (i.e., each 20-year age class occupying 36 percent of the commercial forest acreage)—more than high enough to accommodate the bars in the lower right corner of figure 12. The corresponding data for major classes of ownership are these:

	<u>Average rotation</u> (in years)	<u>Rectangle height</u> (in percent)
Private holdings:		
Large	77	26
Medium	63	32
Small	56	36
Public holdings:		
National Forest	80	25
Other	75	27

On the basis of these data, and referring now to figures 15-18 in Appendix A, one concludes that there is evidence of gaps here and there in all major categories of forest ownership except National Forest. Gaps are found primarily in the Puget Sound district, secondarily in the Columbia River district. Few if any indications of gaps are to be discovered in these summary charts for National Forests in any part of the subregion or for any class of ownership in the southwest Oregon district. However, it is clear that abnormalities in the age-class distribution appear more and more widely as one examines smaller and smaller categories of forest. Surely, marked departures from the ideal are very common among individual forest holdings—at least among private forest properties outside the southern part of the subregion. It is this condition of the forest resource that has led to widespread discussion and some trial of the cooperative sustained-yield-unit idea.

In the last analysis, there is just one sort of remedy for the raw material problems that abnormal age-class distributions create for individual manufacturers of wood products. The remedy is to take advantage of the subregion's gap-free aggregate age class arrangement. This, in turn, means relying upon the market and upon transportation facilities to let the overages that exist on some holdings go to cancel out the underages on others. Much of the flow of overage toward underage is a flow of public timber to private firms. Since this is the direction of the flow anyhow, the issue resolves itself into that of the volume of flow.

Yields if Present Trends Continue

Attention is turned now to the second of the three questions asked at the beginning of this chapter: If present trends in forest management and timber cutting should continue, what changes might occur in timber output and growing stock, and what might be the contingent problems? In an effort to answer this question, the inventory for the 1950's was taken as the starting point for a careful and detailed bookkeeping projection to the year 2000, followed by a summary projection thence for an additional forest rotation period.

For the detailed projection, estimates of timber growth (see Appendix B) and timber cut were used to calculate successive timber inventories applying to the years 1970, 1980, 1990, and 2000. These inventories, of acreage and of the quantity of sawtimber, were worked up separately for each stand-age class in each

ownership and type-site class in each of the districts of the Douglas-fir subregion. The estimated harvests were recorded in the same detail. Allowances were made for the changes in land use and forest ownership, the "principal assumption" postulated in chapter 2, and for forest losses through fire, storm, and other destructive agencies.

The detailed projection was based upon assumptions that were developed in consultation with private and public forestry officials within the subregion. It was assumed that on much of the public forest the allowable cuts current in 1960 would continue in effect and be fully harvested.³ On private forests, the basic harvest would be a given percentage of current inventory, ranging from 2 percent on large private holdings in the Puget Sound district to 6 percent on small private holdings in the Southwest Oregon. Thus provision was made for distinguishing between slow cutters and fast cutters on the basis of holding size and of district. It was assumed that the basic cut of each owner would be taken mostly from his oldest remaining age classes of forest, but allowance was made for some harvest cutting in younger stands.

Besides the basic cut of timber on private and public lands, an additional cut resulted from the assumption that a thinning regime would be introduced over the years. The assumptions made about thinning were, for example, that among large private holdings on type-sites 1 and 2, 50 percent of the young-growth forest would be in a thinning program by 1990. For public forests, the assumed percentage was 25. Necessary transportation and marketing developments would accompany and make possible these advances in silviculture. They would go hand in hand, also, with a growing program of salvage cuts, prelogging, relogging, and the like for older stands, designed to recapture timber lost through mortality and to tighten standards of timber utilization on both private and public lands.

The summary projection that was applied to the decades following 2000 was kept consistent, so far as possible, with the assumptions of the detailed projection for earlier decades. The procedure was essentially that of a trial projection followed by an area-volume check such as is used in setting an allowable cut for a forest property. Yield estimates, but no forecasts of ending inventory, were obtained in this projection.

A fuller explanation of the projection assumptions and procedures, as well as detailed tables and graphs of the results, is made in Appendix C.

The detailed projection for the period 1960-2000 will be taken up first, beginning with the question of yields. A summary of estimated outputs, decade by decade, for the Douglas-fir subregion as a whole is given in table 20. The data are subdivided by district in tables 52 through 54, Appendix C.

³ Between the time this study was begun and January 1963, the total allowable cut for public lands was increased by about 10 percent to reflect shortened rotations, better inventory and growth data, and other factors. This new level of cut could not be incorporated into the details of this report. This actual increase is believed to be within the context of the present trends projection. For example, the 3,028 million board feet of output shown in table 20 for the National Forests during the decade of the 1960's compares favorably with the National Forest allowable cut of 2,987 million board feet as of January 1963.

Yields over time, 1960-2000.—Looking, for the moment, only at the "all" line in each decade group in table 20, one observes that if present trends continue, the output from all commercial forest lands of the subregion—the harvest cuts, thinings, salvage, and the rest, both live and dead timber—will average about 11.6 billion board feet per year during the four decades, 1960-2000. This figure is in terms of standing timber equivalent, the same terms used throughout this report except in the very few cases which are clearly noted.

The 40-year average output of 11.6 billion board feet is close to the actual average annual cut in the decade of the 1950's, 11.5 billion feet in terms of standing timber. Indeed, the projected output holds fairly steady from decade to decade, especially after the first decade, which is the only one of the four in which the average annual output is expected to deviate from the 40-year average by more than 4 percent.

Table 20. — Prospective annual output of timber in the Douglas-fir subregion if present trends continue, by decade, ownership class, and source of output, 1960-2000
(In million board feet)

Source of output	Private holdings				Public holdings				Public and private holdings
	Large	Medium	Small	All	National Forest	Other Federal	Other	All	
Reduction of inventory									
Replaced by growth	1,064	526	1,374	2,964	1,717	581	104	2,402	5,366
Salvage	3,085	191	951	4,227	1,063	476	505	2,044	6,271
	327	43	28	398	248	113	39	400	798
All	4,476	760	2,353	7,589	3,028	1,170	648	4,846	12,435
DECADE OF 1970's									
Reduction of inventory									
Replaced by growth	609	303	884	1,796	1,543	570	18	2,131	3,928
Salvage	3,339	241	744	4,324	1,297	505	728	2,531	6,855
	282	17	--	299	322	118	33	472	770
All	4,230	561	1,628	6,419	3,162	1,193	779	5,134	11,553
DECADE OF 1980's									
Reduction of inventory									
Replaced by growth	92	221	687	1,000	1,590	469	35	2,094	3,094
Salvage	3,924	215	543	4,682	1,243	644	771	2,658	7,340
	200	8	1	209	377	134	42	553	762
All	4,216	444	1,231	5,891	3,210	1,247	848	5,305	11,196
DECADE OF 1990's									
Reduction of inventory									
Replaced by growth	474	53	281	808	1,421	628	69	2,118	2,926
Salvage	4,036	320	560	4,916	1,490	511	770	2,771	7,687
	164	3	1	168	362	107	38	507	675
All	4,674	376	842	5,892	3,273	1,246	877	5,396	11,288

It should, of course, be noted that the rather level trend foreseen for timber harvests is in terms of total board feet of physical volume. The character of wood in the board foot is not expected to be just the same at the end of the period as at the beginning. Nor will the uses and value of a board foot be just the same, nor the quantity of other wood produced along with a board foot. The changes expected are the normal and usual changes of a transition era.

Yields related to geography and ownership.—Beneath the somewhat steady board foot output projected for the whole forest lie some compensating trends. An upward trend is anticipated for the Puget Sound district as more and more young-growth timber ascends to merchantability and as its output is augmented by thinning. In the other two districts, output is expected to decline somewhat, thus shifting the gravity center of the wood industry slightly northward again after many decades to the southward.

Also, some exchange between private and public cuts is anticipated. In recent years, close to 70 percent of the subregion's timber output has derived from private lands. A continuation of current trends would result in a persistent reduction in the private cut, notably in the Southwest Oregon and Columbia River districts, and a corresponding increase in the public cut in all districts. The percentages of total output by decade are:

Decade:	<u>Private cut</u>	<u>Public cut</u>
1960's	61	39
1970's	56	44
1980's	53	47
1990's	52	48

The projected decline in the private timber harvest is paced by the small holdings. Here, shrinkage both in total acres and in growing stock per acre is expected to trim the output by half during the 30 years between the 1960's and the 1990's. The reduction will be severest in the Southwest Oregon district and least in the Puget Sound. Such prospects are in line with the landownership and management changes foreseen in chapter 2.

Projected increases in the public timber harvest are shared rather uniformly among districts and classes of holdings. These increases, it must be noted, are calculated despite the assumption that there will be no change in allowable cuts of old growth if present trends continue. The increases stem from the assumption of steady improvements in silviculture and wood utilization.

Composition of yields.—The total timber output trend projected for the period 1960-2000 also contains some compensating changes in the composition of the cut. Some of the major changes anticipated are the following:

1. A shift in the regional harvest toward a larger percentage of young-growth timber as the liquidation of old growth progresses.
2. A closely related shift away from cutting not replaced by timber growth toward cutting that is replaced—that is, a movement toward sustained yield management based on growth. This shift is reflected in the first two lines within each decade group in table 20 (and in tables 43 through 45). Here, "reduction in inventory" signifies cutting (both thinning and final harvest) that comes out of inventory in the sense that it serves to reduce total inventory in that ownership class in any district. "Replaced by growth" signifies cutting (again, both thinning and final harvest) that is replaced by growth and so does not reduce inventory in the

district. It is well to remark that the "reduction in inventory" figures may exceed the inventory reductions that are actually anticipated, since they omit net changes in inventory in any ownership class and district. Likewise, "replaced by growth" is only that part of growth expected to be cut and not necessarily the total growth.

3. A marked rise in the quantity of thinnings in young growth and of various salvage and utilization cuts other than the main harvest in old growth. The thinning projections, which are included in the "reduction in inventory" and "replaced by growth" lines of table 20 (and of tables 43 through 45) are separately displayed in table 21. The projections of the other types of cut are recorded in the "salvage lines" of the tables. In the total amount of all such cuttings, the Columbia River district is expected to lead the others in all decades.

Table 21. — Prospective annual timber output from thinnings in the Douglas-fir subregion and its three districts if present trends continue, by ownership class and decade, 1960-2000

(In million board feet)

DOUGLAS-FIR SUBREGION									
Decade	Private holdings				Public holdings				All holdings
	Large	Medium	Small	Total	National Forest	Other Federal	Other	Total	
1960's	106	17	31	154	9	3	8	20	174
1970's	287	38	53	378	25	18	45	88	466
1980's	557	58	68	683	32	28	87	147	830
1990's	1,063	90	62	1,215	63	58	113	234	1,449
PUGET SOUND DISTRICT									
1960's	45	3	12	60	1	(1)	6	7	67
1970's	109	8	20	137	5	1	23	29	166
1980's	205	14	25	244	7	1	38	46	290
1990's	331	40	12	383	15	1	39	55	438
COLUMBIA RIVER DISTRICT									
1960's	44	13	18	75	8	1	2	11	86
1970's	143	23	26	192	18	8	21	47	239
1980's	286	34	35	355	22	12	48	82	437
1990's	486	40	36	562	39	27	68	134	696
SOUTHWEST OREGON DISTRICT									
1960's	17	1	1	19	(1)	2	(1)	2	21
1970's	35	7	7	49	2	9	1	12	61
1980's	66	10	8	84	3	15	1	19	103
1990's	246	10	14	270	9	30	6	45	315

¹ Less than 1/2 million board feet.

4. A general increase in timber growth, not only aggregate as reflected in table 20, but also per forest acre (table 22) and percent of growing stock (table 23). On public lands, aggregate growth rises from 30 percent of that on all holdings in the 1960's to 36 percent in the 1990's. This is the consequence mainly of cleaning up and clearing away old timber and of launching a thinning program for younger stands. However, the growth rates achieved by the year 2000 are still far below par and indicate need to accelerate management if higher level of growth is to be reached. On private lands, growth rates are markedly higher than on public. The differences revealed in tables 22 and 23 among the three classes of private holdings result in part from a purely statistical cause: the shifts in private forest ownerships that were built into the projection.

From a glance back over the four major points that have been made about changes in composition of the cut if present trends continue, it is obvious that the topic of growth, in one guise or another, dominates these points. Growth is what will permit the total harvest to be maintained. And the level of growth—that is, the efficiency of the timber resource—stands out as the principal issue when present trends are evaluated.

Forest inventory in 2000.—If the yields anticipated under a continuation of present trends are indeed harvested, then one may expect the forest of the Douglas-fir subregion to change very greatly in timber quantity and in composition by the year 2000.

Table 22. — Prospective annual timber growth per acre of commercial forest land in the Douglas-fir subregion and its three districts if present trends continue, by ownership class and decade, 1960-2000

(In board feet)

DOUGLAS-FIR SUBREGION

Decade	Private holdings				Public holdings				All holdings
	Large	Medium	Small	Total	National Forest	Other Federal	Other	Total	
1960's	470	182	253	352	141	187	258	172	265
1970's	454	204	163	329	173	206	418	225	279
1980's	520	209	140	382	166	256	407	230	308
1990's	453	416	233	396	201	205	401	238	320

PUGET SOUND DISTRICT

1960's	469	295	239	365	152	257	212	179	290
1970's	442	411	205	357	167	268	420	261	318
1980's	557	360	167	422	162	238	406	251	353
1990's	449	376	151	365	147	265	372	230	310

COLUMBIA RIVER DISTRICT

1960's	542	188	347	420	158	267	336	212	320
1970's	569	134	180	384	222	287	435	276	332
1980's	590	153	149	416	209	335	436	275	348
1990's	499	406	205	415	271	275	441	306	363

SOUTHWEST OREGON DISTRICT

1960's	328	60	69	194	103	134	—	110	146
1970's	255	87	52	174	99	153	266	126	146
1980's	340	58	69	253	103	213	180	149	193
1990's	378	590	483	406	134	159	276	148	258

The sawtimber inventory projected for the year 2000 is about 465 billion board feet—little more than seven-tenths of the inventory in the decade of 1950's. The projected inventory for the Puget Sound district is down 15 percent; for the Columbia River district, down 26 percent; for the Southwest Oregon district, down 45 percent. The heaviest percentage reductions are generally in the categories of small and medium-size private holdings. National Forest inventories in the subregion are reduced in about the same proportion as all holdings together, some 30 percent. Such a reduction, with approximately sustained output, means a 40- to 45-percent rise in efficiency of the growing stock.

Table 23. — Prospective annual timber growth as a percentage of growing stock in the Douglas-fir subregion and its three districts if present trends continue, by ownership class and decade, 1960-2000

(In percent)

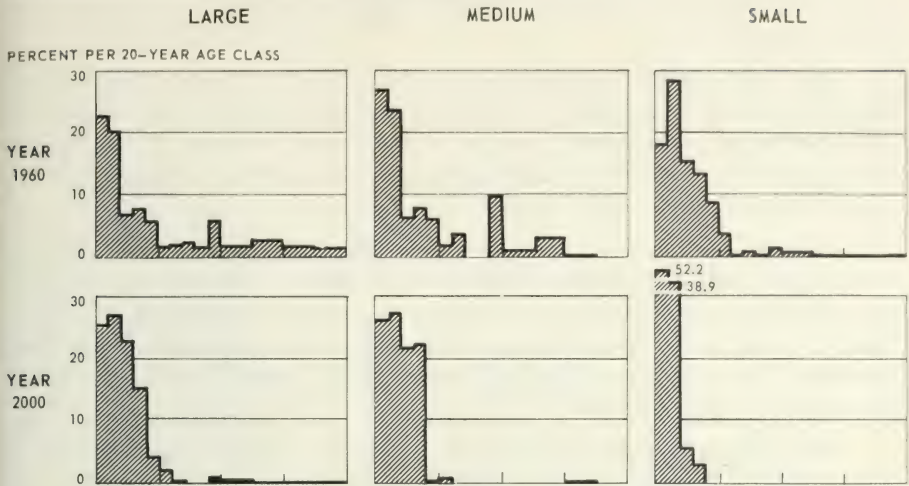
DOUGLAS-FIR SUBREGION									
Decade	Private holdings				Public holdings				All holdings
	Large	Medium	Small	Total	National Forest	Other Federal	Other	Total	
1960's	2.1	1.6	3.3	2.3	0.4	0.8	1.5	0.6	1.2
1970's	2.4	2.0	2.4	2.3	.5	1.0	2.3	.8	1.3
1980's	3.0	2.1	2.9	2.9	.5	1.4	2.1	.8	1.5
1990's	2.9	3.8	3.0	3.0	.7	1.2	2.0	.9	1.6
PUGET SOUND DISTRICT									
1960's	2.0	2.4	3.4	2.3	0.4	1.8	0.9	0.6	1.3
1970's	2.1	3.5	2.8	2.3	.5	1.8	3.5	.9	1.5
1980's	2.8	3.1	2.3	2.7	.5	1.5	1.6	.9	1.7
1990's	2.4	3.4	2.2	2.4	.5	1.8	1.5	.9	1.5
COLUMBIA RIVER DISTRICT									
1960's	2.2	1.4	3.9	2.5	0.4	1.0	2.9	0.6	1.3
1970's	2.6	1.1	2.3	2.5	.6	1.2	3.3	.9	1.4
1980's	3.0	1.4	2.4	2.8	.6	1.5	2.9	.9	1.6
1990's	2.9	3.5	3.5	3.0	.8	1.4	2.7	1.0	1.7
SOUTHWEST OREGON DISTRICT									
1960's	1.8	0.9	1.3	1.7	0.4	0.6	1.3	0.5	0.8
1970's	2.2	1.5	1.6	2.1	.4	.8	1.6	.6	.9
1980's	3.9	1.0	3.1	3.7	.4	1.2	1.1	.7	1.3
1990's	5.1	6.2	12.2	6.0	.6	1.0	2.0	.8	1.8

How the commercial forest acreage will be distributed by stand-age class in 2000 if present trends continue, and how the distribution compares with that of today, is summarized for the Douglas-fir subregion in figure 13, and for the three districts, in figures 19-24 in Appendix C. These figures treat only of stocked, coniferous forests. It is estimated that 10 percent of the commercial forest acreage in 2000 will be nonstocked. And 7 percent will be in hardwood cover. A great deal of this hardwood forest will be on small private holdings in the north and central districts of the subregion.

Figure 13 makes clear how strongly the forest age distributions are expected to shift toward the younger classes during the era 1960-2000, particularly on private holdings. By the end of the 40 years, each of the three classes of private holdings will show aggregate age-class distributions somewhat resembling the

PROSPECTIVE AGE-CLASS DISTRIBUTION

PRIVATE HOLDINGS IN THE DOUGLAS-FIR SUBREGION



PUBLIC HOLDINGS IN THE DOUGLAS-FIR SUBREGION

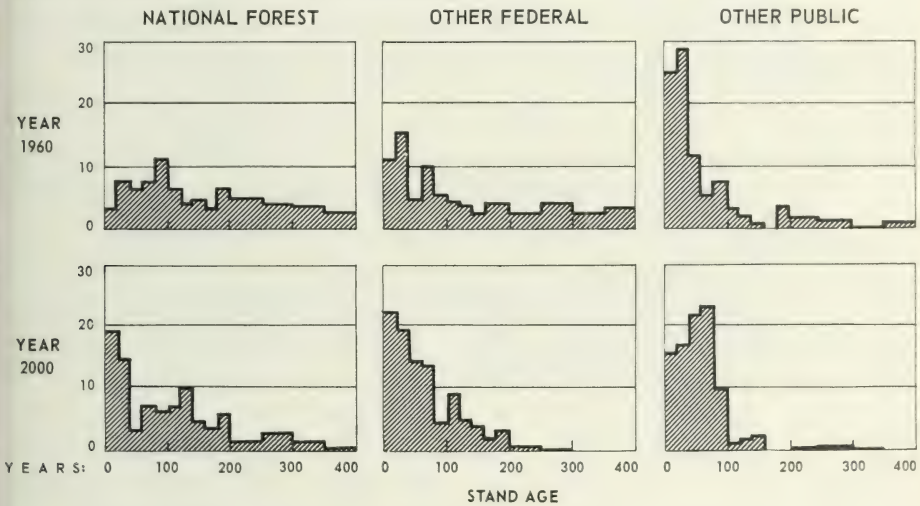


Figure 13.—Distribution of even-aged coniferous commercial forest area by stand-age class for major classes of ownership, Douglas-fir subregion, 1960 and 2000, if present trends continue.

ideal distributions represented in the tabulation on page 92. Non-Federal public holdings, too, will be approaching an ideal distribution in the aggregate. On the National Forests, however, more than half of the area will still be in stands older than 100 years.

Yields after 2000.—The summary projection made for the years beyond 2000 affords a general view of the far outlook if present trends continue. The results of the projection are presented in table 24 and charted in figure 14. Data from table 20 have been added in order to show the entire series of 11 decades studied in the detailed and summary projections.

From the last column in table 24 and in figure 14 it appears that the even tenor of total output promised for the next four decades can be sustained thereafter—indefinitely, it would seem—if present trends in timber programs continue. Potential total outputs after the year 2000 are, in fact, more stable than those preceding. They climb gradually, reaching the longrun annual level of 13.1 billion board feet by the year 2070.

The projected aggregate outputs from the major categories of private and of public lands are also quite steady from decade to decade as they move in the direction of the longrun potential. The same tendencies are to be traced, also, within the separate districts of the Douglas-fir subregion (not shown in table 24). Minor fluctuations here and there in the projected output have no real significance, since they could have been eliminated in the bookkeeping process by slightly different allocations of allowable cuts between adjacent decades.

Table 24. — Prospective annual output of timber in the Douglas-fir subregion if present trends continue, by ownership class and decade, 1960-2070

(In billion board feet)

Decade	Private holdings				Public holdings				All holdings
	Large	Medium	Small	Total	National Forest	Other Federal	Other	Total	
1960's	4.5	0.8	2.3	7.6	3.0	1.2	0.6	4.8	12.4
1970's	4.2	.6	1.6	6.4	3.2	1.2	.8	5.2	11.6
1980's	4.2	.5	1.2	5.9	3.2	1.2	.9	5.3	11.2
1990's	4.7	.4	.8	5.9	3.3	1.2	.9	5.4	11.3
2000's	5.2	.4	.9	6.5	3.1	1.2	1.1	5.4	11.9
2010's	5.4	.4	.8	6.6	3.3	1.2	1.2	5.7	12.3
2020's	5.5	.4	.6	6.5	3.4	1.3	1.3	6.0	12.5
2030's	5.5	.4	.6	6.5	3.6	1.3	1.3	6.2	12.7
2040's	5.5	.4	.6	6.5	3.7	1.4	1.3	6.4	12.9
2050's	5.5	.3	.7	6.5	3.9	1.0	1.3	6.2	12.7
2060's	5.5	.3	.9	6.7	4.0	1.1	1.3	6.4	13.1

PROSPECTIVE ANNUAL OUTPUT

DOUGLAS-FIR SUBREGION

BILLION BOARD FEET, SCRIBNER RULE

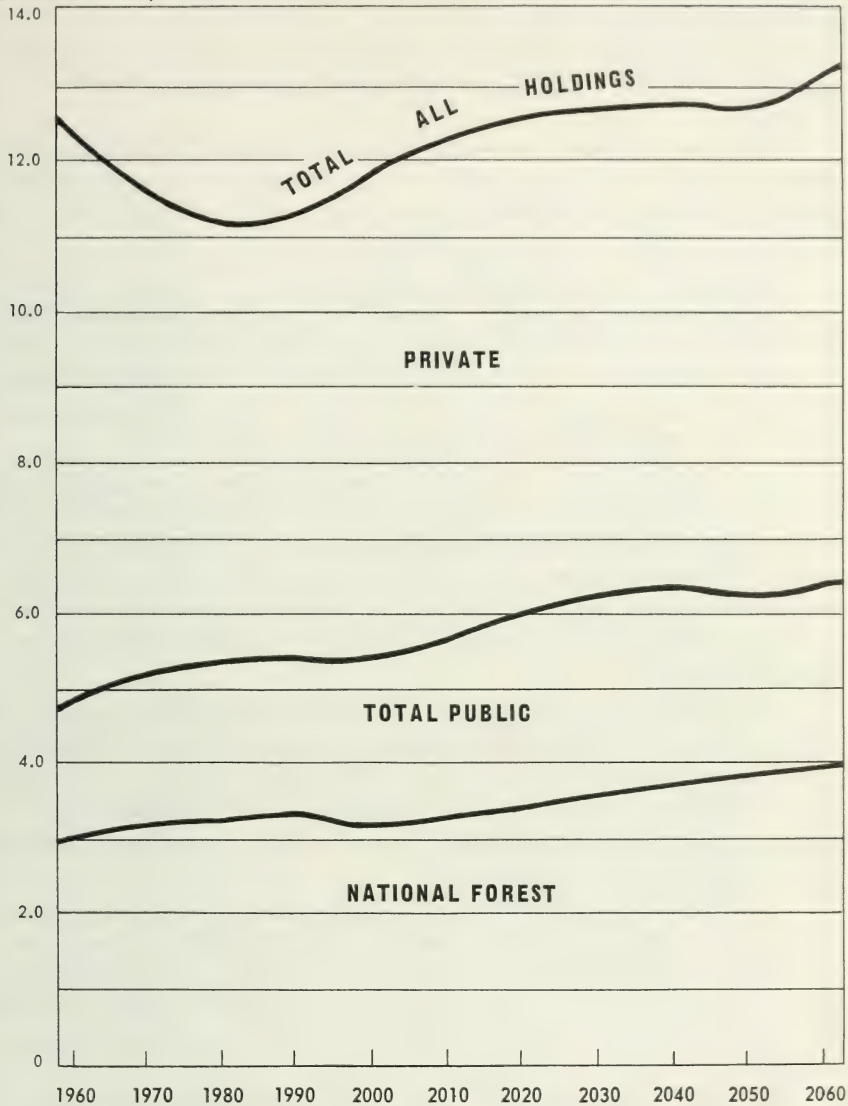


Figure 14.—Prospective annual output of timber in the Douglas-fir subregion if present trends continue, by ownership class, 1960-2070.

Problems and Opportunities of the Transition Period

The purpose of this final section is to examine briefly the last of the three questions asked in the introduction to this chapter. What are the possibilities if forest management were intensified faster than present trends suggest and if the subregion's old-growth timber were converted to young-growth more rapidly than is now intended, and what problems are likely to arise during such an accelerated transition?

There are, of course, many alternatives to the output that is in prospect with present trends. Future cutting levels can be varied over a rather wide range, depending particularly upon cutting policies relating to old-growth stands. Management programs can be of greatly different intensities.

Possibilities for increasing timber output depend, for example, on the degree to which reforestation technology is further developed and investments in planting accelerated beyond the levels assumed in Appendix C. Such action could assure prompter replacement of harvested stands and early restocking of the extensive backlog of cutover nonstocked lands in the region. Improved planting techniques are of critical importance in making possible an increase in cuts.

More rapid development of thinning, salvage cutting, prelogging, relogging, or other types of cutting associated with intensive management could also permit larger timber harvests in both the short and long run. Such intensification of utilization will depend upon existence of markets for the material produced. This in turn will depend in part on the rate at which old-growth timber is liquidated and the general growth of demand for lumber and other wood products in the Nation's markets.

More rapid cutting of old-growth timber also could lead to a greater aggregate cut of timber, both over the next few decades and over the coming century. This could only be achieved, however, at the expense of disrupting the timber industry in the future when it would be necessary to lower available supply to the longrun regulated forest potential, and only if successful conversion to well-stocked young stands could be assured.

In the case of forests with a considerable excess of age classes beyond rotation age, a more rapid harvest of old growth could produce a greater total yield over time than with present trends because the growth of young stands is greater than in old-growth forests. One trial projection of such accelerated conversion, for example, indicated that total yields during the next century might be increased as much as 12 percent by such cutting policies.

By shifting capital out of low efficiency uses to higher efficiency uses in forestry or other business alternatives—acceleration of cutting—the total level of regional and national income and employment might well be increased. Within the region's forest industries, expanding plant capacity and accelerating the cut at this time would, of course, lead in turn to later declines in log supplies.

Accelerating the cut of old-growth timber in the short run also would undoubtedly act to depress prices of stumpage and manufactured products to some

degree. On the one hand, this could well prevent or delay the utilization of thinnings and other material of relatively low value. On the other hand, such accelerated cutting might well strengthen the incentive of private forest owners to reduce their own cut and to use more public timber instead; this in turn could lead to deferment of cutting in the younger age classes and a building up of the age classes that must provide the log supplies of the future. The rate of market expansion for products of the Douglas-fir region is, of course, of critical importance in determining impacts of accelerated cutting within the region and in competing areas.

Adequate consideration of the many possible modifications of present management and cutting trends in the Douglas-fir region and evaluation of the varied impacts on the region's economy that might result from alternative policies are of large practical significance. Such questions, however, must necessarily be the subject of future analyses that will supplement this initial study of the timber situation and outlook in the Douglas-fir region.



Appendix A

Forest Inventory

Tables 25-32 show commercial forest acreage, total and per acre board foot volume (Scribner rule) of live sawtimber, and total and per acre cubic foot volume of all growing stock by type-site and ownership classes in the Douglas-fir sub-region and each of its three districts as mapped in figure 1. Tables 25-32, on acreage, are further subdivided by stand-age class, as are figures 15-18, which illustrate percentages of forest land area.

For the most part, the data apply to the year of most recent Forest Survey inventory in each county inventoried since 1953 and to the late 1950's in the case of other counties. The resulting period of reference is termed "decade of 1950's."

The terms used in the tables are to be interpreted according to the standard definitions of the Forest Survey, with the exception of "land class" and "type-site."

"Land class" is a subdivision of nonstocked areas into (1) burns and old cutovers and (2) recent cutovers.

"Type-site" is a subdivision of all commercial forest lands into five groups on the basis of forest type and site class: Type-site 1 includes forests of the Douglas-fir, western hemlock, Sitka spruce, western redcedar, and sugar pine types on Douglas-fir sites I and II and forests of the ponderosa pine type on pine sites I and II. Type-site 2 includes the same group of forest types on Douglas-fir site III and ponderosa pine sites III and IV. Type-site 3 includes the same group of forest types on Douglas-fir sites IV and V and ponderosa pine sites V and VI. Type-site 4 includes all other conifer types—notably the true fir types, fir-mountain hemlock, Engelmann spruce, western larch, and western white and lodgepole pines—on all sites. Type-site 5 includes hardwood forests on all sites. These definitions may be arranged in tabular form as follows:

Type-site	Douglas-fir, western hemlock, Sitka spruce, western redcedar, and sugar pine forest types	Ponderosa pine forest type	Other conifer forest types—e.g., true fir, fir-mountain hemlock, Engelmann spruce, western larch, western white pine, lodgepole pine	Hardwood forest types
1	Douglas-fir sites I and II	Ponderosa pine sites I and II	None	None
2	Douglas-fir site III	Ponderosa pine sites III and IV	None	None
3	Douglas-fir sites IV and V	Ponderosa pine sites V and VI	None	None
4	None	None	All sites	None
5	None	None	None	All sites

The first four type-sites also include nonstocked commercial forest lands attributed to them by the method described hereinafter.

The following steps were taken in developing the inventory:

Of the 38 counties in the Douglas-fir subregion, 20 counties, well distributed geographically and believed to be representative of forest conditions, were designated as inventory counties. Every sample plot cluster examined in the field on the most recent Forest Survey of each inventory county was classified by stand-size, type-site, ownership, and stand-age classes. To supplement the field sample, which covered primarily sawtimber and poletimber stands, a sample of seedling and sapling stands and nonstocked areas was taken in the office on forest type and site maps. Again, every sample point was classified by forest stand size, type-site, ownership, and stand age (or, for nonstocked areas, land class). The forest type attributed to a nonstocked sample point was the type of the nearest area stocked with conifers.

The stand-size, type-site, ownership, and stand-age or land-class information for each plot cluster and sample point was tabulated along with the total commercial forest acreage, total board foot volume, and total cubic foot volume of growing stock represented by each cluster or point. From the tabulations for each district was computed the percentage of the total forest acreage, board foot volume, and cubic foot volume in each ownership and stand-size class that fell into each type-site and age (or land) class.

An inventory was drawn up for each district of the total commercial forest acreage, total board foot volume of sawtimber, and total cubic foot volume of growing stock by class of ownership and stand-size class. The inventory was taken from Forest Survey records. For all counties resurveyed since 1953, the records were accepted without change. For most other counties, the records were brought up to date by bookkeeping methods designed to allow for interim changes in forest area, ownership, and stand-size class, and in timber volumes as a result of growth and depletion. These inventory totals were then subdivided by type-site and age (or land) classes in accordance with the percentages derived from the analysis of plot clusters and sample points. Finally, the data for all stand-size classes were combined to provide estimates of forest acreage and timber volume by district, type-site class, ownership class, and stand-age (or land) class.

The great detail to which the inventory has been carried has one disadvantage: that data in some of the resulting categories are based upon very few sample plots and, consequently, may be wide of the mark and must be accepted with caution. In general, the smaller the acreage in any forest category (tables 25-32, the larger the error to which any data for that category are subject.

Table 25. — Area of commercial forest land, by type-site, ownership, and stand-age classes, Douglas-fir subregion, decade of 1950's

(In thousand acres)

ALL TYPE-SITE CLASSES

Land class or stand age	Private holdings			Public holdings			All holdings
	Large	Medium	Small	National Forest	Other Federal	Other	
Burns and old cutovers	210	36	222	112	134	211	925
Recent cutovers	248	156	219	222	125	67	1,037
1-20 years	1,086	395	1,038	223	247	596	3,585
21-40 years	1,148	405	1,680	516	350	574	4,673
41-60 years	309	115	939	436	104	249	2,152
61-80 years	355	105	672	491	214	108	1,945
81-100 years	260	89	431	679	149	144	1,752
101-120 years	89	26	199	369	98	63	844
121-140 years	116	50	28	249	84	40	567
141-160 years	129	--	60	284	54	16	543
161-180 years	61	--	51	215	93	1	421
181-200 years	297	129	72	387	84	70	1,039
201-250 years	206	41	148	744	138	89	1,366
251-300 years	354	106	88	624	224	62	1,458
301-350 years	262	12	47	578	136	10	1,045
351 years or older	223	10	9	363	175	49	829
Uneven aged	95	68	218	1,001	163	40	1,585
All classes	5,448	1,743	6,121	7,493	2,572	2,389	25,766

TYPE-SITE 1

Burns and old cutovers	116	19	89	6	16	134	380
Recent cutovers	189	61	94	21	44	10	419
1-20 years	703	201	436	65	93	290	1,788
21-40 years	387	104	491	37	36	250	1,305
41-60 years	194	49	339	53	8	95	738
61-80 years	229	68	229	187	159	82	954
81-100 years	135	45	178	265	40	96	759
101-120 years	37	13	29	91	46	--	216
121-140 years	17	--	13	17	3	30	80
141-160 years	26	--	--	32	--	8	66
161-180 years	29	--	--	27	33	--	89
181-200 years	190	21	28	45	72	--	356
201-250 years	56	--	30	66	13	5	170
251-300 years	231	24	23	77	112	--	467
301-350 years	120	3	--	122	72	5	322
351 years or older	83	3	9	87	66	15	263
Uneven aged	37	7	74	130	54	31	333
All classes	2,779	618	2,062	1,328	867	1,051	8,705

TYPE-SITE 2

Burns and old cutovers	73	17	99	22	42	67	320
Recent cutovers	54	83	89	41	60	15	342
1-20 years	302	144	378	100	106	171	1,201
21-40 years	446	88	505	115	152	177	1,483
41-60 years	79	33	240	107	55	52	566
61-80 years	90	21	251	114	44	23	543
81-100 years	105	8	125	187	47	33	505
101-120 years	43	9	46	110	10	13	231
121-140 years	79	--	13	60	52	5	209
141-160 years	42	--	31	65	23	5	166
161-180 years	23	--	17	28	45	1	114
181-200 years	85	--	24	74	6	28	217
201-250 years	64	6	41	164	89	--	364
251-300 years	31	76	26	116	86	20	355
301-350 years	97	--	13	164	10	--	284
351 years or older	49	7	--	124	76	34	290
Uneven aged	46	37	40	258	51	5	437
All classes	1,708	529	1,938	1,849	954	649	7,627

Table 25. — Area of commercial forest land, by type-site, ownership, and stand-age classes, Douglas-fir subregion, decade of 1950's—Continued

(In thousand acres)

TYPE-SITE 3							
Land class or stand age	Private holdings			Public holdings			All holdings
	Large	Medium	Small	National Forest	Other Federal	Other	
Burns and old cutovers	17	--	27	31	62	5	142
Recent cutovers	--	5	36	114	21	21	197
1-20 years	18	8	40	22	31	17	136
21-40 years	88	106	300	190	125	115	924
41-60 years	32	3	136	160	35	70	436
61-80 years	36	8	143	119	3	--	309
81-100 years	20	25	120	148	50	14	377
101-120 years	9	--	109	101	40	49	308
121-140 years	9	50	2	95	--	5	161
141-160 years	59	--	29	137	31	--	256
161-180 years	--	--	23	95	13	--	131
181-200 years	9	108	20	138	5	11	291
201-250 years	73	29	61	251	33	49	496
251-300 years	73	6	39	252	23	27	420
301-350 years	44	8	34	165	54	5	310
351 years or older	91	--	--	125	33	--	249
Uneven aged	--	23	55	337	52	--	467
All classes	578	379	1,174	2,480	611	388	5,610
TYPE-SITE 4							
Burns and old cutovers	4	--	7	53	14	5	83
Recent cutovers	5	7	--	46	--	21	79
1-20 years	2	--	--	17	--	--	19
21-40 years	3	16	14	126	7	3	169
41-60 years	4	1	--	90	3	--	98
61-80 years	--	8	2	45	3	1	59
81-100 years	--	4	--	71	--	--	75
101-120 years	--	4	--	63	2	--	69
121-140 years	8	--	--	75	29	--	112
141-160 years	2	--	--	49	--	3	54
161-180 years	9	--	--	64	2	--	75
181-200 years	13	--	--	129	1	31	174
201-250 years	13	6	16	262	3	35	335
251-300 years	19	--	--	179	3	15	216
301-350 years	1	1	--	127	--	--	129
351 years or older	--	--	--	27	--	--	27
Uneven aged	10	1	1	264	2	--	278
All classes	93	48	40	1,687	69	114	2,051
TYPE-SITE 5							
1-20 years	61	42	184	19	17	118	441
21-40 years	224	91	370	48	30	29	792
41-60 years	--	29	224	26	3	32	314
61-80 years	--	--	47	26	5	2	80
81-100 years	--	7	8	8	12	1	36
101-120 years	--	--	15	4	--	1	20
121 years or older	3	--	11	6	--	--	20
Uneven aged	2	--	48	12	4	4	70
All classes	290	169	907	149	71	187	1,773

Table 26. — Area of commercial forest land, by type-site, ownership, and stand-age classes, Puget Sound district, decade of 1950's

(In thousand acres)

ALL TYPE-SITE CLASSES

Land class or stand age	Private holdings			Public holdings			All holdings
	Large	Medium	Small	National Forest	Other Federal	Other	
Burns and old cutovers	69	7	--	32	27	--	135
Recent cutovers	95	27	17	--	--	41	180
1-20 years	456	48	332	67	13	220	1,136
21-40 years	607	145	925	174	54	310	2,215
41-60 years	130	36	294	85	13	137	695
61-80 years	127	22	139	61	19	8	376
81-100 years	72	16	69	93	10	59	319
101-120 years	8	--	17	35	--	49	109
121-140 years	52	--	2	78	3	25	160
141-160 years	84	--	1	89	--	--	174
161-180 years	29	--	11	78	--	--	118
181-200 years	110	15	13	100	1	41	280
201-250 years	21	27	6	251	--	81	386
251-300 years	119	--	42	227	3	42	433
301-350 years	68	6	--	252	--	--	326
351 years or older	95	--	--	120	4	25	244
Uneven aged	--	14	48	3	5	25	95
All classes	2,142	363	1,916	1,745	152	1,063	7,381

TYPE-SITE 1

Burns and old cutovers	28	7	--	--	--	--	35
Recent cutovers	95	20	--	--	--	--	115
1-20 years	302	25	105	22	--	59	513
21-40 years	140	3	245	3	3	118	512
41-60 years	58	9	91	1	--	32	191
61-80 years	72	14	18	--	--	--	104
81-100 years	60	--	11	18	--	59	148
101-120 years	8	--	--	5	--	--	13
121-140 years	4	--	--	5	3	25	37
141-160 years	20	--	--	19	--	--	39
161-180 years	20	--	--	19	--	--	39
181-200 years	85	15	1	17	--	--	118
201-250 years	4	--	--	1	--	--	5
251-300 years	41	--	--	18	--	--	59
301-350 years	8	--	--	21	--	--	29
351 years or older	4	--	--	24	--	--	28
Uneven aged	--	--	--	--	3	25	28
All classes	949	93	471	173	9	318	2,013

TYPE-SITE 2

Burns and old cutovers	28	--	--	--	9	--	37
Recent cutovers	--	--	12	--	--	--	12
1-20 years	111	15	138	33	8	79	384
21-40 years	212	22	248	40	1	104	627
41-60 years	60	26	55	16	7	29	193
61-80 years	49	--	59	32	16	8	164
81-100 years	--	--	26	36	--	--	62
101-120 years	--	--	17	25	--	--	42
121-140 years	40	--	--	9	--	--	49
141-160 years	21	--	1	25	--	--	47
161-180 years	--	--	--	6	--	--	6
181-200 years	23	--	--	28	--	--	51
201-250 years	3	--	--	52	--	--	55
251-300 years	9	--	3	26	--	--	38
301-350 years	20	--	--	49	--	--	69
351 years or older	--	--	--	38	4	25	67
Uneven aged	--	14	21	1	--	--	36
All classes	576	77	580	416	45	245	1,939

Table 26. — Area of commercial forest land, by type-site, ownership, and stand-age classes, Puget Sound district, decade of 1950's—Continued

(In thousand acres)

Land class or stand age	PRIVATE HOLDINGS			PUBLIC HOLDINGS			All holdings
	Large	Medium	Small	National Forest	Other Federal	Other	
Burns and old cutovers	13	--	--	--	9	--	22
Recent cutovers	--	--	5	--	--	21	26
1-20 years	15	5	19	4	5	14	62
21-40 years	50	79	219	74	30	73	525
41-60 years	11	1	77	61	5	50	205
61-80 years	6	8	38	27	3	--	82
81-100 years	12	9	24	18	--	--	63
101-120 years	--	--	--	5	--	49	54
121-140 years	--	--	2	23	--	--	25
141-160 years	42	--	--	45	--	--	87
161-180 years	--	--	--	26	--	10	26
181-200 years	--	--	12	25	--	10	47
201-250 years	13	22	--	76	--	49	160
251-300 years	60	--	39	99	3	27	228
301-350 years	40	6	--	95	--	--	141
351 years or older	91	--	--	37	--	--	128
Uneven aged	--	--	12	2	--	--	14
All classes	353	130	447	617	55	293	1,895

TYPE-SITE 4

Burns and old cutovers	--	--	--	32	9	--	41
Recent cutovers	--	7	--	--	--	20	27
1-20 years	2	--	--	7	--	--	9
21-40 years	3	--	6	45	5	2	61
41-60 years	1	--	--	5	--	--	6
61-80 years	--	--	--	--	--	--	--
81-100 years	--	--	--	20	--	--	20
101-120 years	--	--	--	--	--	--	--
121-140 years	8	--	--	41	--	--	49
141-160 years	1	--	--	--	--	--	1
161-180 years	9	--	--	27	--	--	36
181-200 years	2	--	--	30	1	31	64
201-250 years	1	5	6	122	--	32	166
251-300 years	9	--	--	84	--	15	108
301-350 years	--	--	--	87	--	--	87
351 years or older	--	--	--	21	--	--	21
Uneven aged	--	--	--	--	--	--	--
All classes	36	12	12	521	15	100	696

TYPE-SITE 5

1-20 years	26	3	70	1	--	68	168
21-40 years	202	41	207	12	15	13	490
41-60 years	--	--	71	2	1	26	100
61-80 years	--	--	24	2	--	--	26
81-100 years	--	7	8	1	10	--	26
101-120 years	--	--	--	--	--	--	--
121 years or older	--	--	11	--	--	--	11
Uneven aged	--	--	15	--	2	--	17
	228	51	406	18	28	107	838

Table 27. — Area of commercial forest land, by type-site, ownership, and stand-age classes, Columbia River district, decade of 1950's

(In thousand acres)

ALL TYPE-SITE CLASSES							
Land class or stand age	Private holdings			Public holdings			All holdings
	Large	Medium	Small	National Forest	Other Federal	Other	
Burns and old cutovers	104	24	165	44	39	208	584
Recent cutovers	96	69	100	35	39	23	362
1-20 years	531	275	521	137	132	366	1,962
21-40 years	488	147	554	270	105	246	1,810
41-60 years	133	79	507	238	40	111	1,108
61-80 years	161	24	391	329	63	43	1,011
81-100 years	140	69	128	472	40	57	906
101-120 years	81	22	98	262	63	14	540
121-140 years	64	--	26	102	20	15	227
141-160 years	45	--	13	114	54	16	242
161-180 years	32	--	17	72	22	--	143
181-200 years	59	13	5	165	12	--	254
201-250 years	96	14	31	278	40	7	466
251-300 years	105	39	--	244	56	20	464
301-350 years	100	6	24	290	37	10	467
351 years or older	128	10	9	216	39	24	426
Uneven aged	78	54	120	293	81	12	638
All classes	2,441	845	2,709	3,561	882	1,172	11,610
TYPE-SITE 1							
Burns and old cutovers	80	12	72	5	16	134	319
Recent cutovers	56	26	68	13	22	9	194
1-20 years	341	157	289	41	51	224	1,103
21-40 years	236	72	195	29	26	131	689
41-60 years	93	40	187	42	8	63	433
61-80 years	90	3	162	179	27	25	486
81-100 years	60	45	51	232	7	37	432
101-120 years	29	13	6	82	13	--	143
121-140 years	13	--	13	10	--	5	41
141-160 years	6	--	--	7	--	8	21
161-180 years	9	--	--	3	--	--	12
181-200 years	18	6	--	18	6	--	48
201-250 years	9	--	6	37	13	5	70
251-300 years	60	16	--	35	13	--	124
301-350 years	62	3	--	99	6	5	175
351 years or older	79	3	9	60	--	15	166
Uneven aged	22	7	28	62	47	5	171
All classes	1,263	403	1,086	954	255	666	4,627
TYPE-SITE 2							
Burns and old cutovers	20	12	88	17	18	67	222
Recent cutovers	36	43	27	18	17	14	155
1-20 years	163	85	146	62	66	91	613
21-40 years	206	42	193	66	29	61	597
41-60 years	19	7	133	71	15	23	268
61-80 years	41	13	123	67	28	15	287
81-100 years	72	8	45	127	14	5	271
101-120 years	43	9	29	70	10	13	174
121-140 years	39	--	13	38	19	5	114
141-160 years	21	--	7	26	23	5	82
161-180 years	23	--	17	10	7	--	57
181-200 years	21	--	--	20	6	--	47
201-250 years	61	6	--	57	24	--	148
251-300 years	22	17	--	54	20	20	133
301-350 years	33	--	13	108	10	--	164
351 years or older	49	7	--	71	6	9	142
Uneven aged	46	23	15	74	13	5	176
All classes	915	272	849	956	325	333	3,650

Table 27. — Area of commercial forest land, by type-site, ownership, and stand-age classes, Columbia River district, decade of 1950's—Continued

(In thousand acres)

TYPE-SITE 3							
Land class or stand age	Private holdings			Public holdings			All holdings
	Large	Medium	Small	National Forest	Other Federal	Other	
Burns and old cutovers	--	--	--	10	--	2	12
Recent cutovers	--	--	5	4	--	--	9
1-20 years	--	3	6	9	4	2	24
21-40 years	30	27	51	87	45	40	280
41-60 years	18	2	34	56	12	19	141
61-80 years	30	--	81	52	--	--	163
81-100 years	8	16	32	85	17	14	172
101-120 years	9	--	48	63	40	--	160
121-140 years	9	--	--	39	--	5	53
141-160 years	17	--	6	52	31	--	106
161-180 years	--	--	--	36	13	--	49
181-200 years	9	7	5	56	--	--	77
201-250 years	16	7	15	92	--	--	130
251-300 years	13	6	--	77	20	--	116
301-350 years	4	2	11	47	21	5	90
351 years or older	--	--	--	81	33	--	114
Uneven aged	--	23	43	81	19	--	166
All classes	163	93	337	927	255	87	1,862

TYPE-SITE 4							
Burns and old cutovers	4	--	5	12	5	5	31
Recent cutovers	4	--	--	--	--	--	4
1-20 years	--	--	--	10	--	--	10
21-40 years	--	--	8	71	2	1	82
41-60 years	3	1	--	60	3	--	67
61-80 years	--	8	2	18	3	1	32
81-100 years	--	--	--	24	--	--	24
101-120 years	--	--	--	47	--	--	47
121-140 years	--	--	--	14	1	--	15
141-160 years	1	--	--	29	--	3	33
161-180 years	--	--	--	23	2	--	25
181-200 years	11	--	--	71	--	--	82
201-250 years	10	1	10	92	3	2	118
251-300 years	10	--	--	78	3	--	91
301-350 years	1	1	--	36	--	--	38
351 years or older	--	--	--	4	--	--	4
Uneven aged	10	1	1	75	2	--	89
All classes	54	12	26	664	24	12	792

TYPE-SITE 5							
1-20 years	27	30	80	15	11	49	212
21-40 years	16	6	107	17	3	13	162
41-60 years	--	29	153	9	2	6	199
61-80 years	--	--	23	13	5	2	43
81-100 years	--	--	--	4	2	1	7
101-120 years	--	--	15	--	--	1	16
121 years or older	3	--	--	1	--	--	4
Uneven aged	--	--	33	1	--	2	36
All classes	46	65	411	60	23	74	679

Table 28. — Area of commercial forest land, by type-site, ownership, and stand-age classes, Southwest Oregon district, decade of 1950's

(In thousand acres)

ALL TYPE-SITE CLASSES							
Land class or stand age	Private holdings			Public holdings			All holdings
	Large	Medium	Small	National Forest	Federal Other	Other	
Burns and old cutovers	37	5	57	36	68	3	206
Recent cutovers	57	60	102	187	86	3	495
1-20 years	99	72	185	19	102	10	487
21-40 years	53	113	201	72	191	18	648
41-60 years	46	--	138	113	51	1	349
61-80 years	67	59	142	101	132	57	558
81-100 years	48	4	234	114	99	28	527
101-120 years	--	4	84	72	35	--	195
121-140 years	--	50	--	69	61	--	180
141-160 years	--	--	46	81	--	--	127
161-180 years	--	--	23	65	71	1	160
181-200 years	128	101	54	122	71	29	505
201-250 years	89	--	111	215	98	1	514
251-300 years	130	67	46	153	165	--	561
301-350 years	94	--	23	36	99	--	252
351 years or older	--	--	--	27	132	--	159
Uneven aged	17	--	50	705	77	3	852
All classes	865	535	1,496	2,187	1,538	154	6,775
TYPE-SITE 1							
Burns and old cutovers	8	--	17	1	--	--	26
Recent cutovers	38	15	26	8	22	1	110
1-20 years	60	19	42	2	42	7	172
21-40 years	11	29	51	5	7	1	104
41-60 years	43	--	61	10	--	--	114
61-80 years	67	51	49	8	132	57	364
81-100 years	15	--	116	15	33	--	179
101-120 years	--	--	23	4	33	--	60
121-140 years	--	--	--	2	--	--	2
141-160 years	--	--	--	6	--	--	6
161-180 years	--	--	--	5	33	--	38
181-200 years	87	--	27	10	66	--	190
201-250 years	43	--	24	28	--	--	95
251-300 years	130	8	23	24	99	--	284
301-350 years	50	--	--	2	66	--	118
351 years or older	--	--	--	3	66	--	69
Uneven aged	15	--	46	68	4	1	134
All classes	567	122	505	201	603	67	2,065
TYPE-SITE 2							
Burns and old cutovers	25	5	11	5	15	--	61
Recent cutovers	18	40	50	23	43	1	175
1-20 years	28	44	94	5	32	1	204
21-40 years	28	24	64	9	122	12	259
41-60 years	--	--	52	20	33	--	105
61-80 years	--	8	69	15	--	--	92
81-100 years	33	--	54	24	33	28	172
101-120 years	--	--	--	15	--	--	15
121-140 years	--	--	--	13	33	--	46
141-160 years	--	--	23	14	--	--	37
161-180 years	--	--	--	12	38	1	51
181-200 years	41	--	24	26	--	28	119
201-250 years	--	--	41	55	65	--	161
251-300 years	--	59	23	36	66	--	184
301-350 years	44	--	--	7	--	--	51
351 years or older	--	--	--	15	66	--	81
Uneven aged	--	--	4	183	38	--	225
All classes	217	180	509	477	584	71	2,038

Table 28. — Area of commercial forest land, by type-site, ownership, and stand-age classes Southwest Oregon district, decade of 1950's—Continued

(In thousand acres)

Land class or stand age	Private holdings			Public holdings			All holdings
	Large	Medium	Small	National Forest	Other Federal	Other	
TYPE-SITE 3							
Burns and old cutovers	4	--	27	21	53	3	108
Recent cutovers	--	5	26	110	21	--	162
1-20 years	3	--	15	9	22	1	50
21-40 years	8	--	30	29	50	2	119
41-60 years	3	--	25	43	18	1	90
61-80 years	--	--	24	40	--	--	64
81-100 years	--	--	64	45	33	--	142
101-120 years	--	--	61	33	--	--	94
121-140 years	--	50	--	33	--	--	83
141-160 years	--	--	23	40	--	--	63
161-180 years	--	--	23	33	--	--	56
181-200 years	--	101	3	57	5	1	167
201-250 years	44	--	46	83	33	--	206
251-300 years	--	--	--	76	--	--	76
301-350 years	--	--	23	23	33	--	79
351 years or older	--	--	--	7	--	--	7
Uneven aged	--	--	--	254	33	--	287
All classes	62	156	390	936	301	8	1,853
TYPE-SITE 4							
Burns and old cutovers	--	--	2	9	--	--	11
Recent cutovers	1	--	--	46	--	1	48
1-20 years	--	--	--	--	--	--	--
21-40 years	--	16	--	10	--	--	26
41-60 years	--	--	--	25	--	--	25
61-80 years	--	--	--	27	--	--	27
81-100 years	--	4	--	27	--	--	31
101-120 years	--	4	--	16	2	--	22
121-140 years	--	--	--	20	28	--	48
141-160 years	--	--	--	20	--	--	20
161-180 years	--	--	--	14	--	--	14
181-200 years	--	--	--	28	--	--	28
201-250 years	2	--	--	48	--	1	51
251-300 years	--	--	--	17	--	--	17
301-350 years	--	--	--	4	--	--	4
351 years or older	--	--	--	2	--	--	2
Uneven aged	--	--	--	189	--	--	189
All classes	3	24	2	502	30	2	563
TYPE-SITE 5							
1-20 years	8	9	34	3	6	1	61
21-40 years	6	44	56	19	12	3	140
41-60 years	--	--	--	15	--	--	15
61-80 years	--	--	--	11	--	--	11
81-100 years	--	--	--	3	--	--	3
101-120 years	--	--	--	4	--	--	4
121 years or older	--	--	--	5	--	--	5
Uneven aged	2	--	--	11	2	2	17
	16	53	90	71	20	6	256

Table 29. — Quantity of live sawtimber in the Douglas-fir subregion, by district, ownership class, and forest type-site class, decade of 1950's

(In million board feet, net Scribner scale)

DOUGLAS-FIR SUBREGION									
Type-site class	Private holdings				Public holdings				All holdings
	Large	Medium	Small	Total	National Forest	Other Federal	Other	Total	
1	92,180	10,936	30,978	134,094	78,391	31,972	16,840	127,203	261,297
2	42,826	8,225	22,581	73,632	78,379	21,506	9,135	109,020	182,652
3	17,802	5,477	10,965	34,244	75,009	7,562	11,448	94,019	128,263
4	5,024	1,125	436	6,587	52,508	844	4,269	57,621	64,208
5	1,607	1,209	4,831	7,647	1,146	745	888	2,779	10,426
All	159,439	26,972	69,793	256,204	285,433	62,629	42,580	390,642	646,846
PUGET SOUND DISTRICT									
1	27,885	1,672	4,022	33,579	10,081	596	6,180	16,857	50,436
2	10,845	900	5,111	16,856	16,192	666	3,881	20,739	37,595
3	10,844	1,380	1,669	13,933	21,691	377	10,407	32,475	46,408
4	1,994	325	245	2,564	19,944	67	3,924	23,935	26,499
5	1,296	446	1,712	3,454	66	334	721	1,121	4,575
All	52,904	4,723	12,759	70,386	67,974	2,040	25,113	95,127	165,513
COLUMBIA RIVER DISTRICT									
1	36,186	7,820	15,072	59,078	58,857	8,797	8,009	75,663	134,741
2	25,954	4,429	12,651	43,034	43,379	10,249	3,855	57,483	100,517
3	5,883	2,488	4,915	13,286	31,727	5,644	1,021	38,392	51,678
4	2,982	241	193	3,416	20,868	317	304	21,489	24,905
5	271	464	3,116	3,851	807	393	134	1,334	5,185
All	71,276	15,442	35,947	122,665	155,638	25,400	13,323	194,361	317,026
SOUTHWEST OREGON DISTRICT									
1	28,109	1,444	11,884	41,437	9,453	22,579	2,651	34,683	76,120
2	6,027	2,896	4,819	13,742	18,808	10,591	1,399	30,798	44,540
3	1,035	1,609	4,381	7,025	21,591	1,541	20	23,152	30,177
4	48	559	--	607	11,696	460	41	12,197	12,804
5	40	299	3	342	273	18	33	324	666
All	35,259	6,807	21,087	63,153	61,821	35,189	4,144	101,154	164,307

Table 30. — Quantity of live sawtimber per acre of commercial forest land in the Douglas-fir subregion, by district, ownership class, and forest type-site class, decade of 1950's

(In board feet, net Scribner scale)

Type-site class	Private holdings				Public holdings				All holdings
	Large	Medium	Small	Total	National Forest	Other Federal	Other	Total	
1	33,168	17,706	15,024	24,565	50,019	36,868	16,028	39,186	30,017
2	25,078	15,553	11,654	17,640	42,402	22,530	14,060	31,575	23,948
3	30,778	14,431	9,344	16,066	30,248	12,371	29,510	27,025	22,861
4	54,211	23,311	10,816	36,307	31,127	12,315	37,496	30,824	31,309
5	5,538	7,161	5,326	5,598	7,656	10,547	4,747	6,821	5,879
All	29,264	15,474	11,403	19,246	38,093	24,348	17,821	31,365	25,104
PUGET SOUND DISTRICT									
1	29,377	18,084	8,544	22,203	58,059	64,244	19,448	33,668	25,054
2	18,818	11,833	8,818	13,683	38,923	14,631	15,785	29,317	19,386
3	30,790	10,554	3,732	14,959	35,189	6,953	35,528	33,702	24,490
4	55,549	26,029	19,240	41,946	38,267	4,562	39,656	37,711	38,083
5	5,704	8,738	4,216	5,047	3,570	11,900	6,707	6,619	5,456
All	24,697	13,018	6,658	15,920	38,935	13,446	23,626	32,132	22,422
COLUMBIA RIVER DISTRICT									
1	28,642	19,430	13,880	21,469	61,671	34,454	12,028	40,342	29,119
2	28,380	16,234	14,902	21,133	45,390	31,553	11,584	35,632	27,542
3	36,082	27,065	14,602	22,458	34,212	22,063	11,641	33,103	27,747
4	55,456	19,610	7,362	37,040	31,469	13,409	24,617	30,735	31,470
5	5,832	7,121	7,586	7,372	13,413	17,281	1,818	8,506	7,634
All	29,197	18,282	13,272	20,464	43,710	28,786	11,362	34,610	27,306
SOUTHWEST OREGON DISTRICT									
1	49,608	11,764	23,518	28,831	47,212	37,469	39,549	39,872	36,870
2	27,786	16,093	9,466	15,168	39,450	18,130	19,682	27,206	21,855
3	16,731	10,263	11,240	11,546	23,066	5,116	2,714	18,603	16,286
4	15,928	23,803	23	21,612	23,272	15,178	15,929	22,778	22,720
5	2,439	5,684	26	2,148	3,648	874	5,819	3,357	2,604
All	40,763	12,709	14,097	21,804	28,273	22,878	26,955	26,082	24,253

Table 31. — Quantity of all growing stock in the Douglas-fir subregion, by district, ownership class, and forest type-site class, decade of 1950's

(In million cubic feet)

DOUGLAS-FIR SUBREGION

Type-site class	Private holdings				Public holdings				All holdings
	Large	Medium	Small	Total	National Forest	Other Federal	Other	Total	
1	15,810	2,176	6,643	24,629	13,479	5,213	3,455	22,147	46,776
2	7,663	1,430	5,002	14,095	13,792	3,744	1,767	19,303	33,398
3	3,334	1,130	2,546	7,010	14,851	1,454	2,244	18,549	25,559
4	978	247	111	1,336	11,062	188	819	12,069	13,405
5	536	317	1,263	2,116	311	168	246	725	2,841
All	28,321	5,300	15,565	49,186	53,495	10,767	8,531	72,793	121,979

PUGET SOUND DISTRICT

1	4,935	327	1,222	6,484	1,599	101	1,292	2,992	9,476
2	2,211	209	1,218	3,638	2,761	137	798	3,696	7,334
3	1,983	336	543	2,862	4,159	79	1,986	6,224	9,086
4	398	64	50	512	3,916	14	750	4,680	5,192
5	460	110	612	1,182	26	85	184	295	1,477
All	9,987	1,046	3,645	14,678	12,461	416	5,010	17,887	32,565

COLUMBIA RIVER DISTRICT

1	6,383	1,490	3,256	11,129	10,171	1,509	1,656	13,336	24,465
2	4,503	776	2,667	7,946	7,426	1,775	728	9,929	17,875
3	1,148	476	1,085	2,709	6,187	1,077	255	7,519	10,228
4	571	57	61	689	4,337	72	62	4,471	5,160
5	65	94	650	809	175	76	52	303	1,112
All	12,670	2,893	7,719	23,282	28,296	4,509	2,753	35,558	58,840

SOUTHWEST OREGON DISTRICT

1	4,492	359	2,165	7,016	1,709	3,603	506	5,818	12,834
2	949	445	1,118	2,512	3,606	1,832	240	5,678	8,190
3	202	317	918	1,437	4,506	298	4	4,808	6,245
4	9	126	--	135	2,808	103	8	2,919	3,054
5	11	114	1	126	110	6	9	125	251
All	5,664	1,361	4,201	11,226	12,739	5,842	767	19,348	30,574

Table 32. — Quantity of all growing stock per acre of commercial forest land in the Douglas-fir subregion, by district, ownership class, and forest type-site class, decade of 1950's

(In cubic feet)

DOUGLAS-FIR SUBREGION									
Type-site class	Private holdings				Public holdings				All holdings
	Large	Medium	Small	Total	National Forest	Other Federal	Other	Total	
1	5,688	3,523	3,222	4,512	10,148	6,011	3,288	6,822	5,373
2	4,489	2,704	2,582	3,377	7,462	3,922	2,720	5,591	4,379
3	5,764	2,978	2,169	3,289	5,989	2,379	5,784	5,332	4,556
4	10,555	5,123	2,726	7,374	6,557	2,748	7,198	6,457	6,537
5	1,846	1,878	1,393	1,549	2,079	2,378	1,314	1,780	1,602
All	5,199	3,041	2,543	3,695	7,139	4,186	3,571	5,845	4,734
PUGET SOUND DISTRICT									
1	5,199	3,536	2,597	4,288	9,210	10,865	4,067	5,977	4,708
2	3,836	2,753	2,101	2,953	6,636	3,012	3,246	5,224	3,782
3	5,611	2,571	1,214	3,073	6,747	1,452	6,779	6,458	4,795
4	11,093	5,122	3,866	8,366	7,515	965	7,578	7,375	7,462
5	2,023	2,144	1,508	1,726	1,408	3,021	1,717	1,917	1,761
All	4,662	2,883	1,902	3,320	7,138	2,740	4,714	5,029	4,412
COLUMBIA RIVER DISTRICT									
1	5,052	3,702	2,999	4,044	10,657	5,912	2,487	7,110	5,287
2	4,924	2,843	3,141	3,902	7,770	5,465	2,190	6,155	4,898
3	7,045	5,181	3,223	4,580	6,671	4,212	2,904	5,916	5,492
4	10,613	4,679	2,335	7,475	6,540	3,004	4,996	6,393	6,519
5	1,395	1,444	1,581	1,548	2,911	3,371	707	1,938	1,638
All	5,190	3,425	2,850	3,884	7,947	5,111	2,348	6,332	5,068
SOUTHWEST OREGON DISTRICT									
1	7,928	2,926	4,284	5,873	8,534	5,978	7,556	6,688	6,216
2	4,377	2,473	2,195	2,773	7,564	3,136	3,380	5,019	4,019
3	3,269	2,026	2,354	2,362	4,813	989	518	3,863	3,370
4	3,082	5,355	10	4,809	5,587	3,402	3,084	5,452	5,420
5	680	2,156	14	791	1,551	321	1,603	1,302	984
All	6,548	2,541	2,809	3,876	5,826	3,798	4,993	4,989	4,513

AGE-CLASS DISTRIBUTION in the 1950's

DOUGLAS-FIR SUBREGION - PRIVATE HOLDINGS

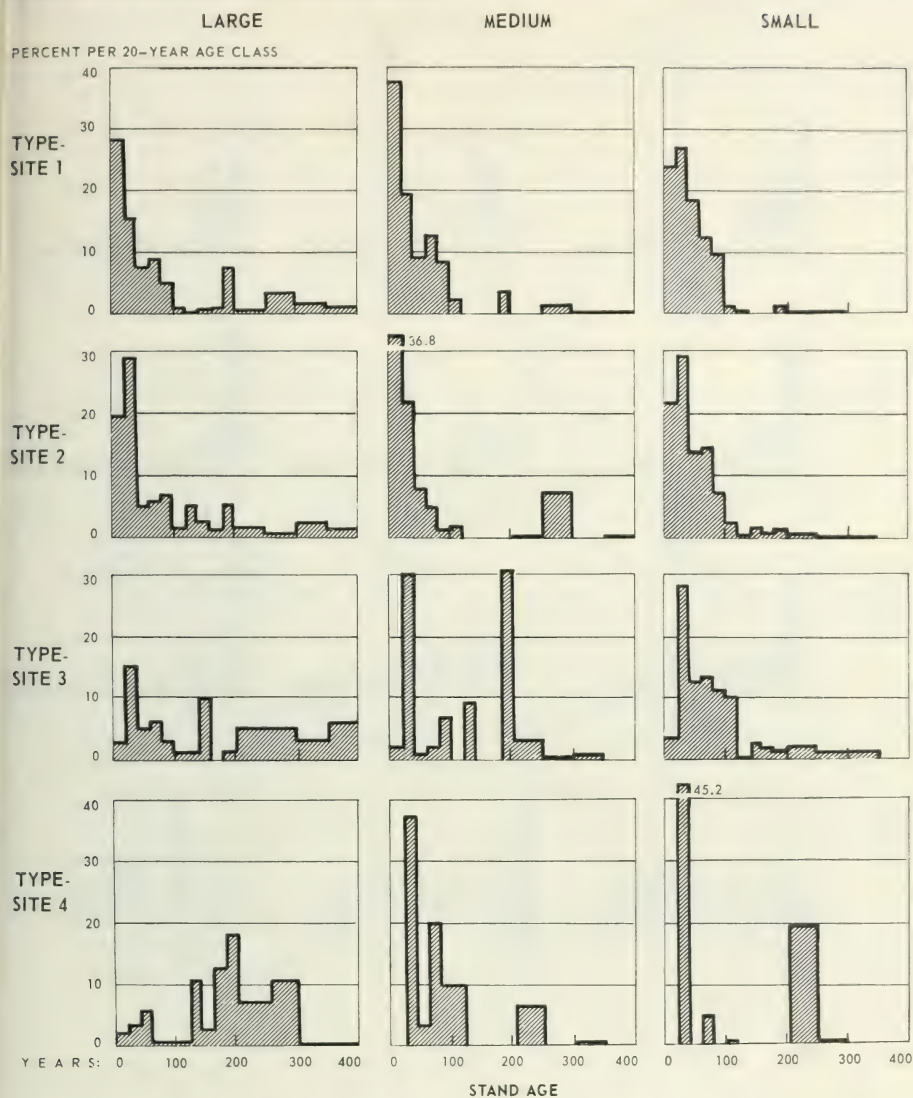


Figure 15.—Age-class distribution of even-aged coniferous commercial forest area in the Douglas-fir subregion, by type-site and ownership classes, decade of 1950's.

AGE-CLASS DISTRIBUTION in the 1950's

DOUGLAS-FIR SUBREGION

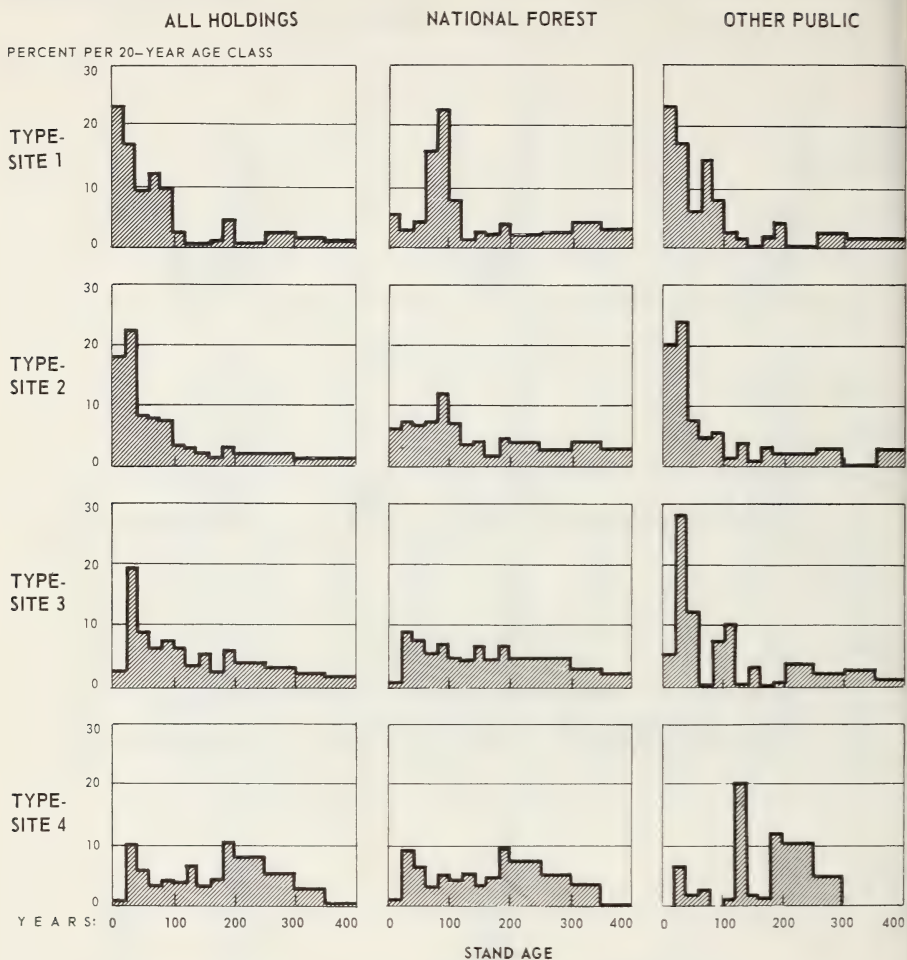


Figure 15.—Age-class distribution of even-aged coniferous commercial forest area in the Douglas-fir subregion, by type-site and ownership classes, decade of 1950's—Continued.

AGE-CLASS DISTRIBUTION in the 1950's **PRIVATE HOLDINGS IN THE PUGET SOUND DISTRICT**

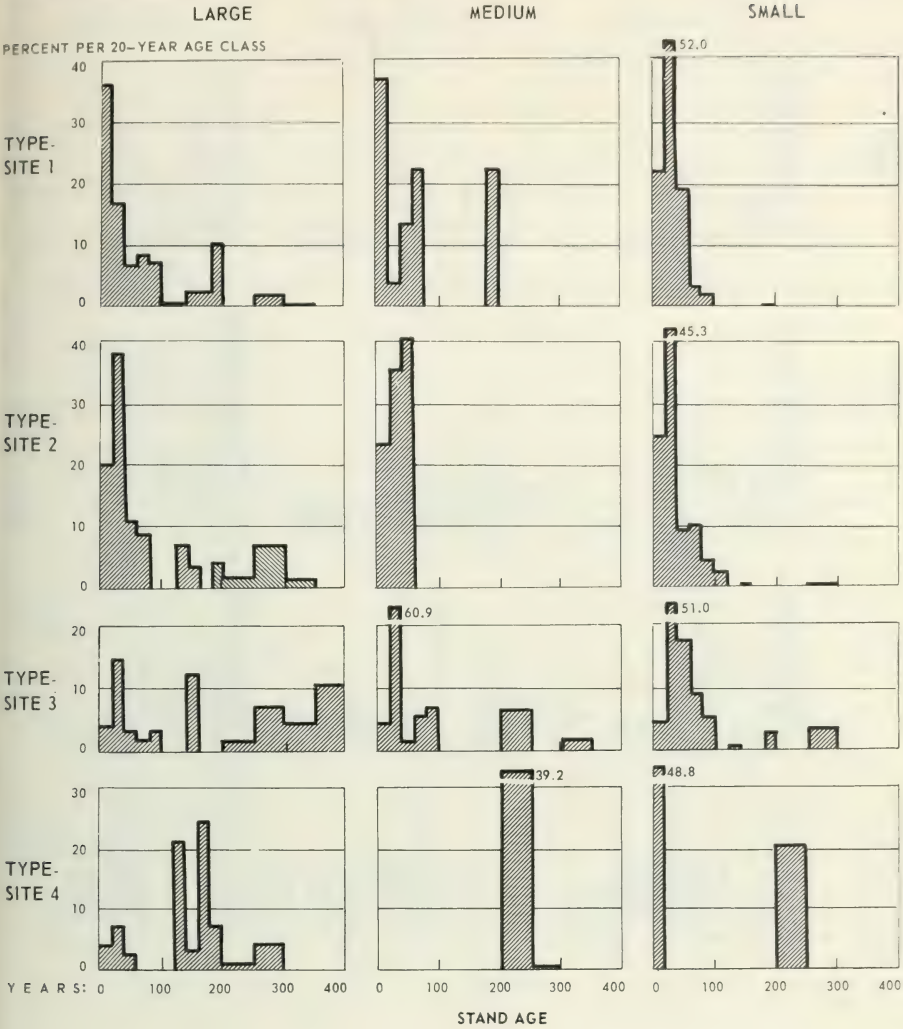


Figure 16.—Age-class distribution of even-aged coniferous commercial forest area in the Puget Sound district, by type-site and ownership classes, decade of 1950's.

AGE-CLASS DISTRIBUTION in the 1950's

PUGET SOUND DISTRICT

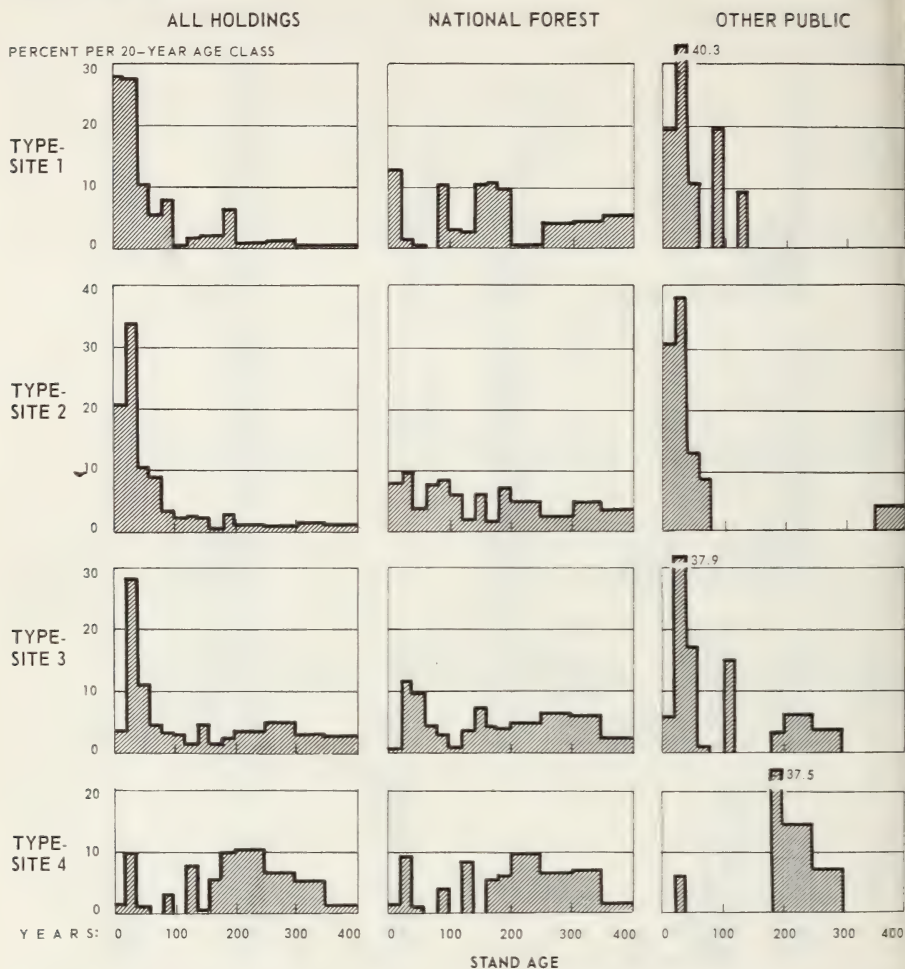


Figure 16.—Age-class distribution of even-aged coniferous commercial forest area in the Puget Sound district, by type-site and ownership classes, decade of 1950's—Continued.

AGE-CLASS DISTRIBUTION in the 1950's

PRIVATE HOLDINGS IN THE COLUMBIA RIVER DISTRICT

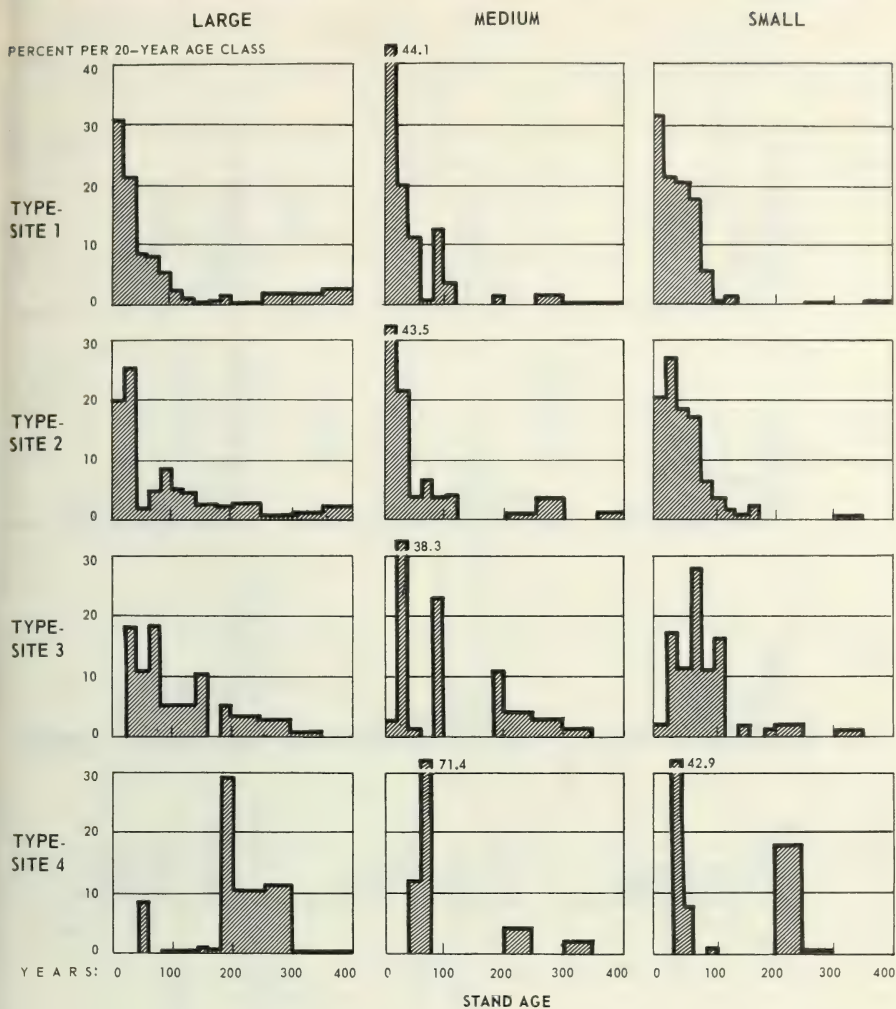


Figure 17.—Age-class distribution of even-aged coniferous commercial forest area in the Columbia River district, by type-site and ownership classes decade of 1950's.

AGE-CLASS DISTRIBUTION in the 1950's

COLUMBIA RIVER DISTRICT

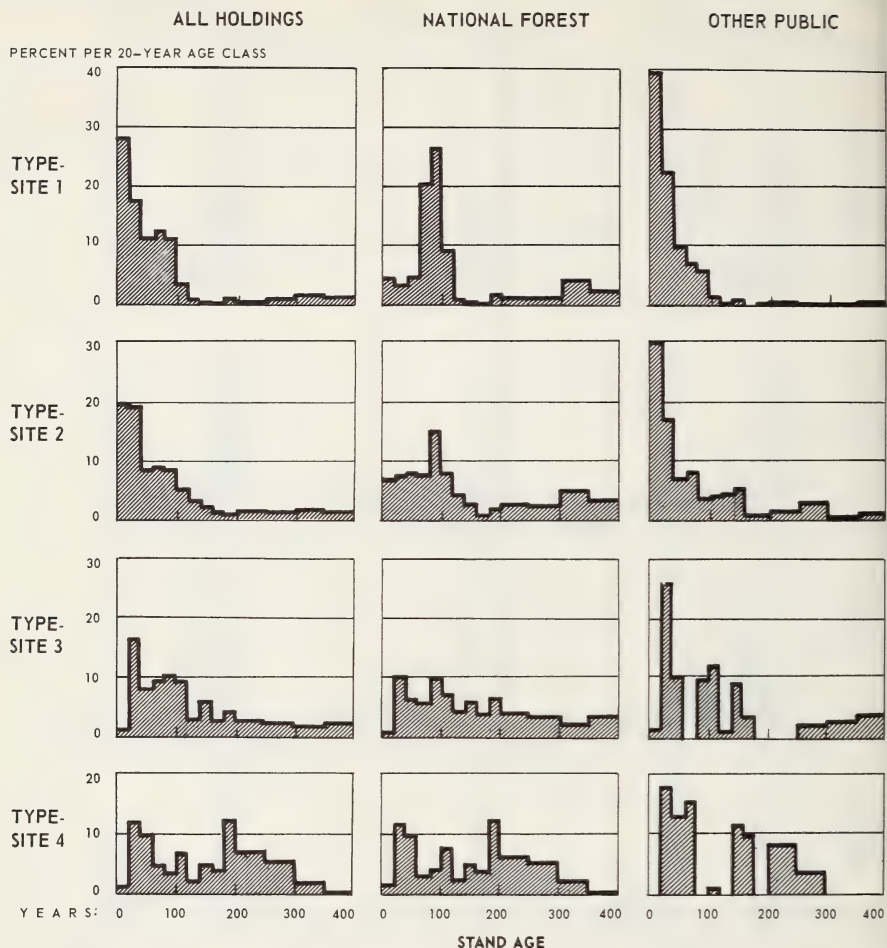


Figure 17.—Age-class distribution of even-aged coniferous commercial forest area in the Columbia River district, by type-site and ownership classes, decade of 1950's—Continued.

AGE-CLASS DISTRIBUTION in the 1950's

PRIVATE HOLDINGS IN SOUTHWEST OREGON

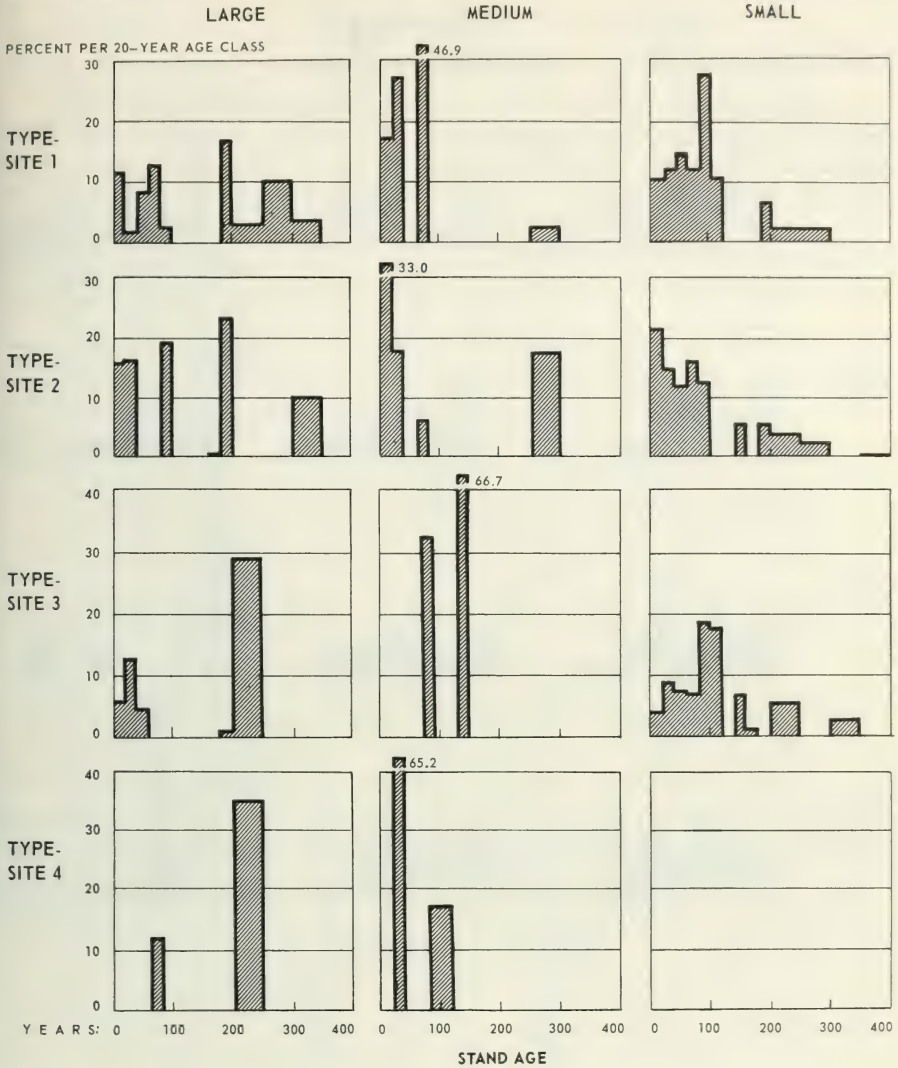


Figure 18.—Age-class distribution of even-aged coniferous commercial forest area in the Southwest Oregon district, by type-site and ownership classes, decade of 1950's.

AGE-CLASS DISTRIBUTION in the 1950's

SOUTHWEST OREGON

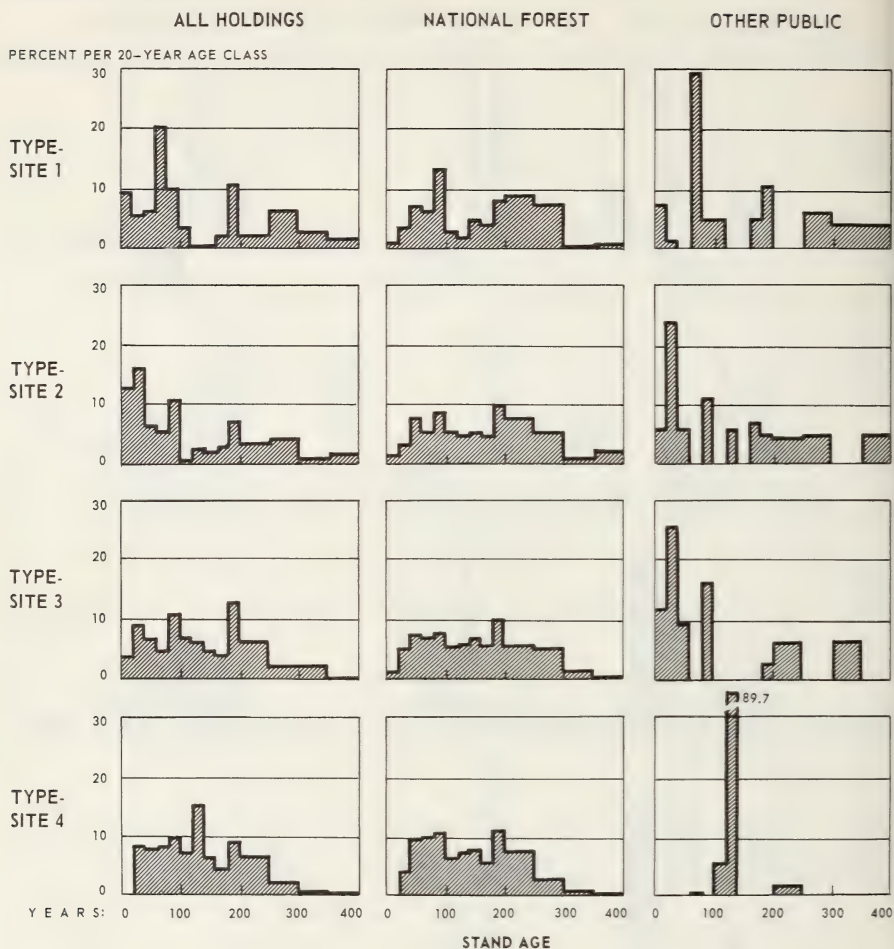


Figure 18.—Age-class distribution of even-aged coniferous commercial forest area in the Southwest Oregon district, by type-site and ownership classes, decade of 1950's—Continued.

Appendix B

Timber Growth

Tables 33-40 show the estimates used in this report of prospective 10-year growth of sawtimber and of all growing stock in forests of type-sites 1, 2, 3, and 4 managed under a thinning regime. The derivation and meaning of the estimates are explained on pages 63 to 66. The estimates were derived in the following form in which growth in percent of that represented in the Douglas-fir normal yield tables is related to stocking in percent of normal for any site class and stand age; the numbers are percentages:

<u>Stocking</u>	<u>Growth of sawtimber</u>	<u>Growth of all growing stock</u>
10	15	17
20	30	34
30	44	51
40	59	68
50	73	84
60	87	100
70	101	116
80	113	130
90	121	139
100	126	145
110	129	148
120	130	149

The estimates, in effect, are of gross growth. They may be compared with the analogous relationships for net growth which are estimated as follows for either sawtimber or all growing stock; the numbers, again, are percentages of normal:

<u>Stocking</u>	<u>Net growth</u>
10	15
20	29
30	42
40	54
50	65
60	75
70	83
80	90
90	96
100	100
110	102
120	103

Tables 41 and 42 are "empirical yield tables" derived by fitting, mathematically, second-degree curves to the basic inventory data on board foot volume per acre in relation to stand age, by type-site class. In table 41, all forest ownership classes are combined; in table 42, only National Forest data are used.

Table 33. — Estimated prospective 10-year growth of sawtimber in a type-site 1 forest under a thinning regime, by age and stocking

(In board feet per acre, Scribner rule)

Age 30		Age 40		Age 50		Age 60		Age 70	
Stocking	Growth	Stocking	Growth	Stocking	Growth	Stocking	Growth	Stocking	Growth
260	1,400	1,190	2,330	2,740	2,310	4,280	2,160	5,720	1,920
520	2,790	2,380	4,650	5,480	4,620	8,560	4,320	11,440	3,840
780	4,090	3,570	6,820	8,220	6,780	12,840	6,340	17,160	5,630
1,040	5,490	4,760	9,150	10,960	9,090	17,120	8,500	22,880	7,550
1,300	6,790	5,950	11,320	13,700	11,240	21,400	10,510	28,600	9,340
1,560	8,090	7,140	13,490	16,440	13,400	25,680	12,530	34,320	11,140
1,820	9,390	8,330	15,660	19,180	15,550	29,960	14,540	40,040	12,930
2,080	10,510	9,520	17,520	21,920	17,400	34,240	16,270	45,760	14,460
2,340	11,250	10,710	18,760	24,660	18,630	38,520	17,420	51,480	15,490
2,600	11,720	11,900	19,530	27,400	19,400	42,800	18,100	57,200	16,130
2,860	12,000	13,090	20,000	30,140	19,870	47,080	18,580	62,920	15,510
3,120	12,090	14,280	20,150	32,880	20,020	51,360	18,720	68,640	16,640

Age 80		Age 90		Age 100		Age 110		Age 120	
Stocking	Growth	Stocking	Growth	Stocking	Growth	Stocking	Growth	Stocking	Growth
7,000	1,650	8,100	1,410	9,040	1,190	9,830	1,020	10,510	890
14,000	3,300	16,200	2,820	18,080	2,370	19,660	2,040	21,020	1,770
21,000	4,840	24,300	4,140	27,120	3,480	29,490	2,990	31,530	2,600
28,000	6,490	32,400	5,550	36,160	4,660	39,320	4,010	42,040	3,480
35,000	8,030	40,500	6,860	45,200	5,770	49,150	4,960	52,550	4,310
42,000	9,570	48,600	8,180	54,240	6,870	58,980	5,920	63,060	5,130
49,000	11,110	56,700	9,490	63,280	7,980	68,810	6,870	73,570	5,960
56,000	12,430	64,800	10,620	72,320	8,930	78,640	7,680	84,080	6,670
63,000	13,310	72,900	11,370	81,360	9,560	88,470	8,230	94,590	7,140
70,000	13,860	81,000	11,800	90,400	9,950	98,300	8,570	105,100	7,430
77,000	14,190	89,100	12,130	99,440	10,190	108,130	8,770	115,610	7,610
84,000	14,300	97,200	12,220	108,480	10,270	117,960	8,840	126,120	7,670

Table 34. — Estimated prospective 10-year growth of sawtimber in a type-site 2 forest under a thinning regime, by age and stocking

(In board feet per acre, Scribner rule)

Age 30		Age 40		Age 50		Age 60		Age 70	
Stocking	Growth	Stocking	Growth	Stocking	Growth	Stocking	Growth	Stocking	Growth
30	630	450	1,180	1,240	1,710	2,380	1,710	3,520	1,580
60	1,260	900	2,370	2,480	3,420	4,760	3,420	7,040	3,150
90	1,850	1,350	3,480	3,720	5,020	7,140	5,020	10,560	4,620
120	2,480	1,800	4,660	4,960	6,730	9,520	6,730	14,080	6,200
150	3,070	2,250	5,770	6,200	8,320	11,900	8,320	17,600	7,670
180	3,650	2,700	6,870	7,440	9,920	14,280	9,920	21,120	9,140
210	4,240	3,150	7,980	8,680	11,510	16,660	11,510	24,640	10,610
240	4,750	3,600	8,930	9,920	12,880	19,040	12,880	28,160	11,870
270	5,080	4,050	9,560	11,160	13,790	21,420	13,790	31,680	12,710
300	5,290	4,500	9,950	12,400	14,360	23,800	14,360	35,200	13,230
330	5,420	4,950	10,190	13,640	14,710	26,180	14,710	38,720	13,550
360	5,460	5,400	10,270	14,880	14,820	28,560	14,820	42,240	13,650

Table 34. — Estimated prospective 10-year growth of sawtimber in a type-site 2 forest under a thinning regime, by age and stocking—Continued

(In board feet per acre, Scribner rule)

Age 80		Age 90		Age 100		Age 110		Age 120	
Stocking	Growth	Stocking	Growth	Stocking	Growth	Stocking	Growth	Stocking	Growth
4,570	1,400	5,500	1,170	6,280	990	6,940	840	7,500	750
9,140	2,790	11,000	2,340	12,560	1,980	13,880	1,680	15,000	1,500
13,710	4,100	16,500	3,440	18,840	2,900	20,820	2,460	22,500	2,200
18,280	5,490	22,000	4,600	25,120	3,890	27,760	3,300	30,000	2,950
22,850	6,790	27,500	5,690	31,400	4,820	34,700	4,090	37,500	3,650
27,420	8,090	33,000	6,790	37,680	5,740	41,640	4,870	45,000	4,350
31,990	9,390	38,500	7,880	43,960	6,670	48,580	5,660	52,500	5,050
36,560	10,510	44,000	8,810	50,240	7,460	55,520	6,330	60,000	5,650
41,130	11,250	49,500	9,440	56,520	7,990	62,460	6,780	67,500	6,050
45,700	11,720	55,000	9,830	62,800	8,320	69,400	7,060	75,000	6,300
50,270	12,000	60,500	10,060	69,080	8,510	76,340	7,220	82,500	6,450
54,840	12,090	66,000	10,140	75,360	8,580	83,280	7,280	90,000	6,500

Table 35. — Estimated prospective 10-year growth of sawtimber in a type-site 3 forest under a thinning regime, by age and stocking

(In board feet per acre, Scribner rule)

Age 30		Age 40		Age 50		Age 60		Age 70	
Stocking	Growth	Stocking	Growth	Stocking	Growth	Stocking	Growth	Stocking	Growth
--	--	20	470	330	720	810	890	1,400	920
--	--	40	930	660	1,440	1,620	1,770	2,800	1,830
--	--	60	1,360	990	2,110	2,430	2,600	4,200	2,680
--	--	80	1,830	1,320	2,830	3,240	3,480	5,600	3,600
--	--	100	2,260	1,650	3,500	4,050	4,310	7,000	4,450
--	--	120	2,700	1,980	4,180	4,860	5,130	8,400	5,310
--	--	140	3,130	2,310	4,850	5,670	5,960	9,800	6,160
--	--	160	3,500	2,640	5,420	6,480	6,670	11,200	6,890
--	--	180	3,750	2,970	5,810	7,290	7,140	12,600	7,380
--	--	200	3,910	3,300	6,050	8,100	7,430	14,000	7,690
--	--	220	4,000	3,630	6,190	8,910	7,610	15,400	7,870
--	--	240	4,030	3,960	6,240	9,720	7,670	16,800	7,930
Age 80		Age 90		Age 100		Age 110		Age 120	
Stocking	Growth	Stocking	Growth	Stocking	Growth	Stocking	Growth	Stocking	Growth
2,010	890	2,600	810	3,140	740	3,630	660	4,070	600
4,020	1,770	5,200	1,620	6,280	1,470	7,260	1,320	8,140	1,200
6,030	2,600	7,800	2,380	9,420	2,160	10,890	1,940	12,210	1,760
8,040	3,480	10,400	3,190	12,560	2,890	14,520	2,600	16,280	2,360
10,050	4,310	13,000	3,940	15,700	3,580	18,150	3,210	20,350	2,920
12,060	5,130	15,600	4,700	18,840	4,260	21,780	3,830	24,420	3,480
14,070	5,960	18,200	5,450	21,980	4,950	25,410	4,440	28,490	4,040
16,080	6,670	20,800	6,100	25,120	5,540	29,040	4,970	32,560	4,520
18,090	7,140	23,400	6,530	28,260	5,930	32,670	5,320	36,630	4,840
20,100	7,430	26,000	6,800	31,400	6,170	36,300	5,540	40,700	5,040
22,110	7,610	28,600	6,970	34,540	6,320	39,930	5,680	44,770	5,160
24,120	7,670	31,200	7,020	37,680	6,370	43,560	5,720	48,840	5,200

Table 36. — Estimated prospective 10-year growth of sawtimber in a type-site 4 forest under a thinning regime, by age and stocking

(In board feet per acre, Scribner rule)

Age 30		Age 40		Age 50		Age 60		Age 70	
Stocking	Growth	Stocking	Growth	Stocking	Growth	Stocking	Growth	Stocking	Growth
--	--	--	--	160	480	480	630	900	735
--	--	--	--	320	960	960	1,260	1,800	1,470
--	--	--	--	480	1,408	1,440	1,848	2,700	2,156
--	--	--	--	640	1,888	1,920	2,478	3,600	2,891
--	--	--	--	800	2,336	2,400	3,066	4,500	3,577
--	--	--	--	960	2,784	2,880	3,654	5,400	4,263
--	--	--	--	1,120	3,232	3,360	4,242	6,300	4,949
--	--	--	--	1,280	3,616	3,840	4,746	7,200	5,537
--	--	--	--	1,440	3,872	4,320	5,082	8,100	5,929
--	--	--	--	1,600	4,032	4,800	5,292	9,000	6,174
--	--	--	--	1,760	4,128	5,280	5,418	9,900	6,321
--	--	--	--	1,920	4,160	5,760	5,460	10,800	6,370
Age 80		Age 90		Age 100		Age 110		Age 120	
Stocking	Growth	Stocking	Growth	Stocking	Growth	Stocking	Growth	Stocking	Growth
1,390	705	1,860	630	2,280	585	2,670	555	3,040	510
2,780	1,410	3,720	1,260	4,560	1,170	5,340	1,100	6,080	1,020
4,170	2,068	5,580	1,848	6,840	1,716	8,010	1,628	9,120	1,496
5,560	2,773	7,440	2,478	9,120	2,301	10,680	2,183	12,160	2,006
6,950	3,431	9,300	3,066	11,400	2,847	13,350	2,701	15,200	2,482
8,340	4,089	11,160	3,654	13,680	3,393	16,020	3,219	18,240	2,958
9,730	4,747	13,020	4,242	15,960	3,939	18,690	3,737	21,280	3,434
11,120	5,311	14,880	4,746	18,240	4,407	21,360	4,181	24,320	3,842
12,510	5,687	16,740	5,082	20,520	4,719	24,030	4,477	27,360	4,114
13,900	5,922	18,600	5,292	22,800	4,914	26,700	4,662	30,400	4,284
15,290	6,063	20,460	5,418	25,080	5,031	29,370	4,773	33,440	4,386
16,680	6,110	22,320	5,460	27,360	5,070	32,040	4,810	36,480	4,420

Table 37. — Estimated prospective 10-year growth of sawtimber in a type-site 1 forest under a thinning regime, by age and stocking

(In cubic feet per acre)

Age 30		Age 40		Age 50		Age 60		Age 70	
Stocking	Growth	Stocking	Growth	Stocking	Growth	Stocking	Growth	Stocking	Growth
330	470	600	390	830	360	1,040	300	1,220	260
650	940	1,200	780	1,660	710	2,080	600	2,430	530
980	1,400	1,800	1,170	2,490	1,070	3,120	890	3,650	790
1,300	1,870	2,400	1,560	3,320	1,430	4,160	1,190	4,860	1,050
1,630	2,310	3,000	1,930	4,150	1,760	5,200	1,470	6,080	1,300
1,950	2,750	3,600	2,300	4,980	2,100	6,240	1,750	7,290	1,550
2,280	3,190	4,200	2,670	5,810	2,440	7,280	2,030	8,510	1,800
2,600	3,580	4,800	2,990	6,640	2,730	8,320	2,280	9,720	2,020
2,930	3,820	5,400	3,200	7,470	2,920	9,360	2,430	10,940	2,160
3,250	3,990	6,000	3,340	8,300	3,050	10,400	2,540	12,150	2,250
3,580	4,070	6,600	3,400	9,130	3,110	11,440	2,590	13,370	2,290
3,900	4,100	7,200	3,430	9,960	3,130	12,480	2,610	14,580	2,310

Table 37. — Estimated prospective 10-year growth of sawtimber in a type-site 1 forest under a thinning regime, by age and stocking—Continued

(In cubic feet per acre)

Age 80		Age 90		Age 100		Age 110		Age 120	
Stocking	Growth	Stocking	Growth	Stocking	Growth	Stocking	Growth	Stocking	Growth
1,370	230	1,510	190	1,620	150	1,710	120	1,780	110
2,740	460	3,010	370	3,230	310	3,410	240	3,550	220
4,110	690	4,520	560	4,850	460	5,120	360	5,330	330
5,480	920	6,020	750	6,460	610	6,820	480	7,100	440
6,850	1,130	7,530	920	8,080	760	8,530	590	8,880	550
8,220	1,350	9,030	1,100	9,690	900	10,230	700	10,650	650
9,590	1,570	10,540	1,280	11,310	1,040	11,940	810	12,430	750
10,960	1,760	12,040	1,430	12,920	1,170	13,640	910	14,200	850
12,330	1,880	13,550	1,530	14,540	1,250	15,350	970	15,980	900
13,700	1,960	15,050	1,600	16,150	1,310	17,050	1,020	17,750	940
15,070	2,000	16,560	1,630	17,770	1,330	18,760	1,040	19,530	960
16,440	2,010	18,060	1,640	19,380	1,340	20,460	1,040	21,300	970

Table 38. — Estimated prospective 10-year growth of sawtimber in a type-site 2 forest under a thinning regime, by age and stocking

(In cubic feet per acre)

Age 30		Age 40		Age 50		Age 60		Age 70	
Stocking	Growth	Stocking	Growth	Stocking	Growth	Stocking	Growth	Stocking	Growth
210	370	430	350	640	310	820	260	970	200
420	750	860	700	1,270	610	1,630	510	1,930	410
630	1,120	1,290	1,050	1,910	920	2,450	770	2,900	610
840	1,500	1,720	1,390	2,540	1,220	3,260	1,020	3,860	820
1,050	1,850	2,150	1,720	3,180	1,510	4,080	1,260	4,830	1,010
1,260	2,200	2,580	2,050	3,810	1,800	4,890	1,500	5,790	1,200
1,470	2,550	3,010	2,380	4,450	2,090	5,710	1,740	6,760	1,390
1,680	2,860	3,440	2,670	5,080	2,340	6,520	1,950	7,720	1,560
1,890	3,060	3,870	2,850	5,720	2,500	7,340	2,090	8,690	1,670
2,100	3,190	4,300	2,970	6,350	2,610	8,150	2,180	9,650	1,740
2,310	3,260	4,730	3,030	6,990	2,660	8,970	2,220	10,620	1,780
2,520	3,280	5,160	3,060	7,620	2,680	9,780	2,240	11,580	1,790
Age 80		Age 90		Age 100		Age 110		Age 120	
Stocking	Growth	Stocking	Growth	Stocking	Growth	Stocking	Growth	Stocking	Growth
1,090	180	1,190	150	1,280	130	1,360	100	1,420	90
2,170	360	2,380	310	2,560	260	2,710	200	2,830	190
3,260	540	3,570	460	3,840	380	4,070	310	4,250	280
4,340	710	4,760	610	5,120	510	5,420	410	5,660	370
5,430	880	5,950	760	6,400	630	6,780	500	7,080	460
6,510	1,050	7,140	900	7,680	750	8,130	600	8,490	550
7,600	1,220	8,330	1,040	8,960	870	9,490	700	9,910	640
8,680	1,370	9,520	1,170	10,240	980	10,840	780	11,320	720
9,770	1,470	10,710	1,250	11,520	1,040	12,200	830	12,740	770
10,850	1,520	11,900	1,310	12,800	1,090	13,550	870	14,150	800
11,940	1,550	13,090	1,330	14,080	1,110	14,910	890	15,570	810
13,020	1,570	14,280	1,340	15,360	1,120	16,260	890	16,980	820

Table 39. — Estimated prospective 10-year growth of sawtimber in a type-site 3 forest under a thinning regime, by age and stocking

(In cubic feet per acre)

Age 30		Age 40		Age 50		Age 60		Age 70	
Stocking	Growth	Stocking	Growth	Stocking	Growth	Stocking	Growth	Stocking	Growth
110	220	240	250	380	240	520	200	640	160
210	440	470	490	760	480	1,040	390	1,270	320
320	660	710	740	1,140	710	1,560	590	1,910	480
420	880	940	990	1,520	950	2,080	780	2,540	650
530	1,090	1,180	1,220	1,900	1,180	2,600	970	3,180	800
630	1,300	1,410	1,450	2,280	1,400	3,120	1,150	3,810	950
740	1,510	1,650	1,680	2,660	1,620	3,640	1,330	4,450	1,100
840	1,690	1,880	1,890	3,040	1,820	4,160	1,500	5,080	1,240
950	1,810	2,120	2,020	3,420	1,950	4,680	1,600	5,720	1,320
1,050	1,890	2,350	2,100	3,800	2,030	5,200	1,670	6,350	1,380
1,160	1,920	2,590	2,150	4,180	2,070	5,720	1,700	6,990	1,410
1,260	1,940	2,820	2,160	4,560	2,090	6,240	1,710	7,620	1,420
Age 80		Age 90		Age 100		Age 110		Age 120	
Stocking	Growth	Stocking	Growth	Stocking	Growth	Stocking	Growth	Stocking	Growth
730	130	810	100	870	90	920	70	960	70
1,460	260	1,610	200	1,730	190	1,840	140	1,920	140
2,190	380	2,420	310	2,600	280	2,760	200	2,880	200
2,920	510	3,220	410	3,460	370	3,680	270	3,840	270
3,650	630	4,030	500	4,330	460	4,600	340	4,800	340
4,380	750	4,830	600	5,190	550	5,520	400	5,760	400
5,110	870	5,640	700	6,060	640	6,440	460	6,720	460
5,840	980	6,440	780	6,920	720	7,360	520	7,680	520
6,570	1,040	7,250	830	7,790	770	8,280	560	8,640	560
7,300	1,090	8,050	870	8,650	800	9,200	580	9,600	580
8,030	1,110	8,860	890	9,520	810	10,120	590	10,560	590
8,760	1,120	9,660	890	10,380	820	11,040	600	11,520	600

Table 40. — Estimated prospective 10-year growth of sawtimber in a type-site 4 forest under a thinning regime, by age and stocking

(In cubic feet per acre)

Age 30		Age 40		Age 50		Age 60		Age 70	
Stocking	Growth	Stocking	Growth	Stocking	Growth	Stocking	Growth	Stocking	Growth
80	170	180	204	300	221	430	170	530	153
160	340	360	408	600	442	860	340	1,060	306
240	510	540	612	900	663	1,290	510	1,590	459
320	680	720	816	1,200	884	1,720	680	2,120	612
400	840	900	1,008	1,500	1,092	2,150	840	2,650	756
480	1,000	1,080	1,200	1,800	1,300	2,580	1,000	3,180	900
560	1,160	1,260	1,392	2,100	1,508	3,010	1,160	3,710	1,044
640	1,300	1,440	1,560	2,400	1,690	3,440	1,300	4,240	1,170
720	1,390	1,620	1,668	2,700	1,807	3,870	1,390	4,770	1,251
800	1,450	1,800	1,740	3,000	1,885	4,300	1,450	5,300	1,305
880	1,480	1,980	1,776	3,300	1,924	4,730	1,480	5,830	1,332
960	1,490	2,160	1,788	3,600	1,937	5,160	1,490	6,360	1,341

Table 40. — Estimated prospective 10-year growth of sawtimber in a type-site 4 forest under a thinning regime, by age and stocking—Continued

(In cubic feet per acre)

Age 80		Age 90		Age 100		Age 110		Age 120	
Stocking	Growth	Stocking	Growth	Stocking	Growth	Stocking	Growth	Stocking	Growth
620	102	680	85	730	85	780	60	815	51
1,240	204	1,360	170	1,460	170	1,560	119	1,630	102
1,860	306	2,040	255	2,190	255	2,340	179	2,445	153
2,480	408	2,720	340	2,920	340	3,120	238	3,260	204
3,100	504	3,400	420	3,650	420	3,900	294	4,075	252
3,720	600	4,080	500	4,380	500	4,680	350	4,890	300
4,340	696	4,760	580	5,110	580	5,460	406	5,705	348
4,960	780	5,440	650	5,840	650	6,240	455	6,520	390
5,580	834	6,120	695	6,570	695	7,020	487	7,335	417
6,200	870	6,800	725	7,300	725	7,800	508	8,150	435
6,820	888	7,480	740	8,030	740	8,580	518	8,965	444
7,440	894	8,160	745	8,760	745	9,360	522	9,780	447

Table 41. — Estimated quantity of live sawtimber per acre of commercial forest land in the Puget Sound and Columbia River districts, by type-site class and stand age, decade of 1950's

(In thousand board feet)

Stand age (years)	Type-site class				
	1	2	3	4	5
30	4.0	3.1	0.5	--	--
40	12.5	8.6	3.6	2.4	6.1
50	20.8	13.9	7.3	5.6	11.4
60	28.6	19.0	10.8	8.6	15.5
70	36.1	23.9	14.1	11.5	19.2
80	43.3	28.6	17.3	14.4	22.0
90	50.1	33.1	20.4	17.2	24.5
100	56.5	37.3	23.3	19.9	26.3
110	62.6	41.4	26.1	22.5	27.5
120	68.3	45.2	28.7	25.0	28.2
130	73.7	48.8	31.2	27.4	28.4
140	78.7	52.2	33.6	29.8	--
150	83.3	55.4	35.8	32.0	--
160	87.6	58.4	37.9	34.2	--
170	91.6	61.2	39.8	36.3	--
180	95.1	63.8	41.6	38.3	--
190	98.4	66.1	43.2	40.2	--
200	101.2	68.3	44.7	42.0	--
210	103.7	70.2	46.1	43.7	--
220	105.9	71.9	47.3	45.4	--
230	107.6	73.4	48.4	47.0	--
240	109.1	74.7	49.3	48.4	--
250	110.2	75.8	50.1	49.8	--
260	110.9	76.7	50.8	51.2	--
270	111.2	77.4	51.3	52.4	--
280	111.2	77.8	51.6	53.5	--
290	--	78.1	51.9	54.6	--
300	--	78.1	52.0	55.5	--
310	--	--	--	56.4	--
320	--	--	--	57.2	--
330	--	--	--	57.9	--
340	--	--	--	58.6	--
350	--	--	--	59.1	--

Table 42. — Estimated quantity of live sawtimber per acre of commercial forest land on national forests in the Southwest Oregon district, by type-site class and stand age, decade of 1950's

(In thousand board feet)

Stand age (years)	Type-site class				
	1	2	3	4	5
30	7.1	5.3	0.5	--	--
40	12.1	8.8	3.2	0.9	0.6
50	16.8	12.3	5.9	3.3	1.6
60	21.4	15.6	8.4	5.7	2.6
70	25.7	18.8	10.9	8.1	3.5
80	29.8	21.9	13.2	10.4	4.4
90	33.6	24.8	15.4	12.6	5.3
100	37.3	27.6	17.6	14.8	6.2
110	40.7	30.3	19.6	16.9	7.0
120	43.9	32.8	21.5	19.0	7.8
130	46.9	35.3	23.3	21.1	8.6
140	49.7	37.6	25.0	23.1	9.4
150	52.3	39.7	26.6	25.0	10.2
160	54.7	41.8	28.0	26.9	11.0
170	56.8	43.7	29.4	28.7	11.8
180	58.7	45.5	30.6	30.5	12.6
190	60.4	47.1	31.8	32.3	13.4
200	61.9	48.6	32.8	34.0	14.1
210	63.2	50.0	33.8	35.6	--
220	64.2	51.3	34.6	37.2	--
230	65.1	52.4	35.3	38.8	--
240	65.7	53.4	35.9	40.3	--
250	66.1	54.3	36.4	41.7	--
260	66.2	55.1	36.8	43.1	--
270	66.2	55.7	37.1	44.5	--
280	--	56.2	37.3	45.8	--
290	--	56.6	37.4	47.0	--
300	--	56.8	--	48.2	--
310	--	56.9	--	49.4	--
320	--	--	--	50.5	--
330	--	--	--	51.5	--
340	--	--	--	52.5	--
350	--	--	--	53.5	--

Appendix C

Future Projections of Present Trends

The detailed timber inventory of the 1950's was projected in 10-year steps to the year 2000 in a detailed projection of cut and growth, making allowance for shifts in landownership and use, losses from fire and catastrophic mortality, reforestation of nonstocked areas, and extra yields from thinning, salvage, prelogging, and relogging.

A summary projection of yield was then carried further from the year 2000 through 2070 to complete an entire rotation on all ownership classes. Individual summary projections were in the form of a conventional area-volume check for each ownership class in each geographic district.

The projection of present trends assumed continuation of current allowable cuts on all public forests and a cutting rate on private lands corresponding to their average cutting rate for the 3 years 1955 to 1957 taken as a percentage of growing stock. Reforestation, salvage of mortality, thinning, prelogging, and relogging were assumed to increase at a modest rate to the year 2000. These rates were different for each ownership class.

Tables 52 and 54 at the end of this appendix show projected yields in the three geographic districts during the four decades 1960-2000 under the projection of present trends. They represent a more detailed breakdown of table 20.

Figures 19 to 24 diagram the projected age-class distributions in 1960 and the year 2000.

Detailed Projections, 1960-2000

The first step in the detailed projections was to update the basic timber inventory of Appendix A to 1960. In the Puget Sound and Columbia River districts, the inventory of the 1950's was taken to represent 1955 and therefore updated 5 years to 1960 by taking into account actual cuts and estimated growth, shifts in landownership and use, fire and catastrophic losses, and reforestation. In the Southwest Oregon district, the actual National Forest inventory was for 1960, and the inventory for other holdings was taken to represent 1950 and updated 10 years to 1960.

The starting inventory was recorded on worksheets showing area and board foot volume for each 20-year age class of every type-site and ownership class for all geographic districts. Every individual entry was termed a projection unit. The identity of each of these projection units was maintained throughout the detailed projection.

The projection procedure was to apply the estimated shifts in landownership and use, losses by fire and catastrophic mortality, yields from thinning, salvage,

prelogging and relogging, and estimated harvest cuts, for each ownership class in each geographic district, to the area and volume inventory of that ownership class for each decade. Growth of the residual stand was then projected to the end of the decade. This procedure was repeated for successive decades to the year 2000.

Growth was estimated from the empirical yield tables of Appendix B. In order to reflect the fact that the 10-year cut would be spread uniformly over the 10 years, one-half of the 10 years' growth was included in the cut for all the area harvested in each decade as part of the harvest yield.

Withdrawals and Shifts in Ownership

Estimated forest land withdrawals and shifts in ownership (see chapter 2) were taken into account uniformly for each decade over the projection period so as to be completed by the year 2000. They were applied at the beginning of each decade before application of cut and growth. In the case of withdrawals for roads and reservoirs, the timber on the withdrawn areas was taken as part of the cut for the decade. Withdrawals and shifts were proportioned among the age classes on the basis of area.

Losses from Fire and Catastrophic Mortality

The following tabulation shows the factors used to estimate annual timber mortality from fire and catastrophic loss:

Decade	Stands 1-35 years	Stands over 35 years
	(Percent of acreage in each age class)	
1950's	0.282	0.134
1960's	.231	.126
1970's	.210	.108
1980's	.187	.100
1990's	.166	.092
2000's	.152	.087

Separate factors were developed for stands under 35 years of age to reflect the greater likelihood of fire occurring in younger stands. Acreage fire losses were based on the 10-year experience of 1948-57. Indicated reductions in the rate of loss are consistent with those used in Timber Resources for America's Future (15, table 279, p. 470).

Catastrophic losses were calculated to have averaged 0.050 percent of commercial forest area per year since 1902. This factor was added uniformly to acreage fire-loss estimates to produce the combined factors shown above.

Estimated volumes salvaged in percent of timber killed by fire or catastrophic loss were determined as follows:

<u>Decade</u>	<u>Present-trends projection</u>
1950's	50
1960's	50
1970's	55
1980's	60
1990's	70

The percentage of salvage is higher in the later years due to anticipated improvements in access and in utilization.

Estimation of Harvest Cuts

Harvest cuts used in the projection included estimates of only the live timber volumes harvested and the estimated salvageable volumes of timber killed by fire and other catastrophe. Extra yields from thinnings, salvage of accumulated and annual mortality, and prelogging and relogging were estimated separately as a supplement to the regular harvest cuts.

Annual harvest cuts on public holdings were assumed to be the allowable cuts reported by the respective managing agencies. For county, municipal, and some State and other public agencies not reporting allowable cuts, the annual cuts were estimated by using rates similar to corresponding properties elsewhere. Except when they were reported otherwise, the annual allowable cuts were assumed to hold for the entire period from 1960 to 2000.

Private harvest cuts were tentatively estimated as a percent of growing stock, using the actual average annual percentage for the 3 years, 1955-57. These percentages were then modified for individual ownership classes to reflect their generally different cutting rates. Large private ownerships were assigned a rate lower than the average. Small private ownerships were assigned a cutting rate above the average. Medium private ownerships were assigned an intermediate rate, generally closer to the rate for the large private ownerships. These rates were determined for each geographic district in such a way that their weighted average would equal the overall percentage first tentatively estimated for all private ownerships combined. The results, used in all four decades, are given in table 43.

The indicated harvest cuts, as described in the two paragraphs above, were applied to the area and volume, by age class, remaining after area and volume to be given thinning treatment were taken out. The volume of any final clear cut of previously thinned areas was considered chargeable to these indicated harvest cuts.

Table 43. — Assumed annual cutting rates (percent of growing stock) on private holdings

Size Class	Puget Sound	Columbia River	Southwest Oregon
	<u>Percent</u>		
Large	2.0	2.5	4.0
Medium	3.0	3.5	4.5
Small	3.7	4.8	6.0
All classes	2.4	3.3	4.7

Table 44. — Economic rotation ages, saw log objective

Type-site	Conservative owner	Intermediate owner	Exploitive owner
	<u>Years</u>		
1	70	55	45
2	80	60	50
3	90	75	55
4	95	80	60

Yields from thinnings, mortality salvage, prelogging, and relogging were estimated separately from harvest cuts. These will be discussed at a later point.

Distribution of Cut Among Type-Site Classes

In allocating the harvest cut (excluding thinnings, salvage, and prelogging yields) among type-site classes, the hardwood cut was determined separately, and the balance distributed among the conifer type-site classes. The hardwood cut in type-site 5 was estimated as a percentage of hardwood inventory volume, as follows:

<u>Decade</u>	<u>Percent</u>
1950's	0.5
1960's	.7
1970's	.9
1980's	1.0
1990's	1.5
2000's	2.0

Analysis of data on hardwood utilization indicated that the current hardwood cut in the Douglas-fir subregion was approximately 0.5 percent of the current inventory in type-site 5. This percent was increased to 1.5 percent for the 1990's to allow for the trend toward increased utilization of hardwoods.

Within each ownership class, the conifer cut was allocated among the four conifer type-site classes in proportion to their inventory volume, except for type-site 4 where a reduction factor was applied to reflect the presently less intensive util-

ization of upper-slope types (table 45). For example, with a one-third factor, one-third of the volume in type-site 4 would be added to the volumes in other conifer type-sites, with the cut distributed in proportion to each type-site's proportion of this total.

Table 45. — Factors applied in allocating cut to type-site 4

Decade	Present-trends projection public and private owners
1960's	1/3
1970's	1/2
1980's	2/3
1990's	3/4

Distribution of Cut Among Age-Classes

Allocation of the indicated harvest cut was made among a wide range of age classes for each type-site and ownership class, except for the hardwood types where for simplicity the cuts were all taken from the oldest age classes. For small private ownerships, the cut was taken first to include 2 percent of the area and volume in each age class 40 years old and over; then, the remainder of the indicated harvest cut was taken from the oldest age classes.

For all other ownerships, the cut included 1 percent of the area and volume in each age class 160 years old and older, with the remainder taken from the oldest age classes.

None of the harvest cut was taken from age classes below the indicated economic rotation ages (table 44) for each ownership class and type-site class. Occasionally, therefore, the actual cut used in the projection was somewhat less than the indicated harvest cut for those private ownerships and type-sites where excess of old growth was small.

Yields from Thinning, Salvage of Mortality, Prelogging, and Relogging

Thinning yields.—Thinning yields were estimated according to basic data of tables 33 through 36, Appendix B, reduced for cull and breakage. Thinnings were assumed to begin in 30-year and older stands and to be repeated each decade until final harvest in the decade following attainment of rotation age. Thinnings on National Forests were assumed to continue until age of culmination of mean annual increment, as shown in the normal yield tables for Scribner board foot log volumes in trees 11.0 inches in diameter and over.

Table 46 shows the estimated percentage of the immature sawtimber area thinned in each decade.

Table 46. — Assumed proportion of immature sawtimber area to be managed under a thinning regime, by ownership class, type-site class, and decade

Decade	Private holdings						Public holdings	
	Large		Medium		Small		Type-sites 1 & 2	Type-sites 3 & 4
	Type-sites 1 & 2	Type-sites 3 & 4	Type-sites 1 & 2	Type-sites 3 & 4	Type-sites 1 & 2	Type-sites 3 & 4		
----- Percent -----								
1960's	15	0	15	0	5	0	5	0
1970's	20	0	20	0	10	0	10	0
1980's	35	0	35	0	15	0	15	0
1990's	50	0	50	0	20	0	25	0

It was assumed that thinnings would be made in hardwood types. The percentages apply to the acreage in each age class between the age of initial thinning and rotation age. Calculated areas to be thinned in each ownership class were allocated among conservative and intermediate owners, as follows:

<u>Owner class</u>	<u>Conservative owners</u> (Percent)	<u>Intermediate owners</u> (Percent)
Large private	85	15
Medium private	20	80
Small private	0	100
National Forests	100	0
Other Federal	85	15
Other public	60	40

Growing stock on thinned areas approximated 60 percent of normal at time of final harvest. This was a result of the thinning program used in the projections. As this is very close to the stocking shown in the empirical yield tables for unthinned stands and in the absence of more definitive information on influence of thinning on final yields, none of the thinning yields were considered chargeable to the indicated harvest cuts. That is, although thinned stands would have less volume at time of final harvest than would the same stands without the last one or two thinnings, it is judged that they probably would have more usable net volume as a result of early thinning than if they had never been thinned, so that none of the thinned volume should, strictly speaking, be chargeable.

Salvage yields.—It was assumed that all except small private owners would construct advance roads to salvage accumulated mortality in stands 120 years and older on type-site classes 1 and 2 and in stands 200 years and older on type-site classes 3 and 4. Initial salvage yields were estimated at 10,000 board feet per acre for type-site 1 and 2 stands over 200 years old and at 5,000 for those 120 to 200 years old. Initial salvage yields from type-sites 3 and 4 were estimated at 5,000 board feet per acre.

Table 47. — Percent of old growth to be advance salvaged as dead material

Decade	Owner class	
	Large and medium private	All public
1960's	10	5
1970's	15	10
1980's	20	15
1990's	25	20

Whenever application of percentages in table 47 produced an area less than that given advance salvage in the previous decade, the area salvaged was increased to that of the previous decade.

All stands previously given advance salvage were assumed to be reworked each decade for salvage of subsequent mortality. Salvage yields were estimated at 80 percent of the periodic mortality after reduction for cull and breakage. Mortality was estimated as the difference between gross growth and net growth per acre given by the empirical yield tables of Appendix B. Table 48 lists estimated net salvage yields.

Table 48. — Net board foot yields per acre from salvage of previous 10-year mortality

(In thousand board feet per acre)

Age	Type-site class			
	1	2	3	4
120	2.6	1.4	--	--
130	2.2	1.4	--	--
140	2.0	1.4	--	--
150	1.8	1.4	--	--
160	1.7	1.4	--	--
170	1.8	1.5	--	--
180	1.8	1.6	--	--
190	1.9	1.7	--	--
200	2.1	1.8	0.8	0.4
210	2.2	1.9	1.0	.4
220	2.4	2.1	1.0	.5
230	2.6	2.2	1.1	.6
240	2.8	2.4	1.3	.6
250	3.0	2.6	1.4	.6
260	3.2	2.7	1.5	.7
270	3.4	2.9	1.6	.8
280	3.5	3.0	1.8	.9
290	3.7	3.2	1.8	1.0
300	3.8	3.4	2.0	1.0
310	4.0	3.5	2.1	1.1
320	4.1	3.7	2.2	1.1
330	4.2	3.8	2.3	1.2
340	4.2	4.0	2.4	1.3

The salvage of mortality existing on clear-cut areas, harvested along with the live cut, was calculated and made a part of harvest cut. These yields were calculated the same as for advance salvage of mortality.

Prelogging and relogging yields.—Prelogging and relogging in stands of high volume per acre increase yields over single stage clear cutting. The extra volume is realized through reduced breakage, and through utilization of tops, small trees, and cull logs not included in the live sawtimber inventory. Much of the material is of pulpwood quality. Table 49 shows percent of clear-cut stands of 40,000 board feet per acre and over that were assumed to be prelogged or relogged. These additional yields were estimated at 10 percent of the net volume per acre.

Table 49. — Percent of clear-cut stands over 40,000 board feet per acre relogged or prelogged

Decade	Large and medium private	Small private	Public owners
1960's	10	0	5
1970's	20	0	10
1980's	30	0	15
1990's	40	0	20

Reforestation

Old burns and cutovers.—Table 50 presents the rate at which the backlog of nonrestocked areas were estimated to become successfully reforested. Areas restocked in each decade were assigned an average age of 5 years at the beginning of the following decade.

Table 50. — Cumulative percent of 1955 backlog of old burns and cutovers reforested

Decade	Private owners			Public owners
	Large	Medium	Small	
1950's	5	5	0	5
1960's	30	30	15	30
1970's	60	60	30	60
1980's	70	70	40	65
1990's	75	75	50	70

New burns and cutovers.—Current burns were considered to be reforested at the same rate as current cutovers in any decade. Table 51 was used to establish the rate of successful reforestation of new burns and cutovers.

Table 51. — Years of delay until successful
reforestation of new cutovers and
new burns

Small private owners		All other owners	
Percent of area	Years of delay	Percent of area	Years of delay
75 25	0-9 10	100	0-10

Review of Projection Procedure

Individual steps in the projection procedure for a single decade are reviewed in the following listing:

1. Area and volume inventory was adjusted for all the age classes of each type-site, ownership class, and geographic district at the beginning of each decade, to take into account shifts in landownership and use. The type-site changes were distributed by age class according to area in each age class.

2. Areas and volumes lost from fire and catastrophic mortality were deducted. Volume salvaged from this source was calculated and included as part of the indicated harvest cut.

3. Area to be managed under a thinning regime was calculated and split into conservative and intermediate owners, and thinning yields were calculated. Any final cuts of thinned areas were included as part of the indicated harvest cut.

4. Cut of type-site 5 was calculated and taken from oldest age classes.

5. Cuts of type-sites 1 to 4 were calculated separately and taken from age classes 40 and over (small private ownerships) or 160 and over (other ownerships). Then the remainder of indicated harvest cut was taken from oldest age classes.

6. One-half of the 10 years' growth on cut areas was included as part of the indicated harvest cuts of steps 4 and 5.

7. Growth from empirical yield tables was applied to remaining inventory of unthinned areas. Growth from thinning schedules was applied to residual thinned stands. This gave starting inventory for the next decade.

8. Volumes of supplemental cuts from advance salvage, salvage on clear cuts, and prelogging and relogging were calculated.

9. Then this formula was applied: total annual cut = indicated harvest cut (final thinning yields + salvage of fire and catastrophic losses + harvest clear cuts) + supplemental cut (thinning yields + advance salvage + salvage on clear cuts + yields from prelogging and relogging).

Summary Projections, 2000-2070

In each district, prospective cuts for one rotation beyond the year 2000 were estimated by decade, using an area-volume check based on the year 2000 inventory for each ownership. Type-site classes were averaged within ownership

classes. Average rotations were applied, derived from those in table 44 according to area of each type-site.

The guiding principle was to sustain the cutting rate of the 1990's throughout the rotation within districts and ownership classes. Occasionally, some reductions were necessary when age-class shortages appeared. Within districts these were mostly compensated for by increased cuts in other ownerships.

Cutting ages were not allowed to drop more than 10 years below rotation except for small private owners, where cutting sometimes was reduced as much as 15 years below rotation age. In all ownerships, the time required to cover the entire area once was not allowed to fall more than 5 years below rotation age.

The trend toward increased thinning was continued beyond 2000. A determination was made of 1990 thinning yield as a percent of clear-cut yield for each ownership class. These percentage figures were increased an additional 5 percent each decade to a maximum of 40 percent of the yield from clear cutting. At the highest level, thinnings constituted 28.6 percent of the total cut.

Due to the complete conversion of old growth in the first decades after 2000, extra yields from prelogging, relogging, and salvage of mortality, other than that realized through thinnings, were assumed to become negligible and were not counted after the year 2000.

Table 52. — Prospective annual output of timber in the Puget Sound district if present trends continue, by decade, ownership class, and source of output, 1960-2000

(In million board feet)

Source of output	Private holdings				Public holdings				All holdings
	Large	Medium	Small	Total	National Forest	Other Federal	Other	Total	
Reduction of inventory	23	35	64	122	437	10	50	487	609
Replaced by growth	1,090	108	413	1,611	270	35	224	529	2,140
Salvage	77	9	13	99	72	2	16	90	189
All	1,190	152	490	1,832	779	37	290	1,106	2,938
DECADE OF 1970's									
Reduction of inventory	77	10	149	226	458	10	10	458	685
Replaced by growth	1,100	137	312	1,549	297	22	392	711	2,260
Salvage	74	7	--	81	96	1	20	117	197
All	1,251	144	461	1,856	851	23	412	1,286	3,142
DECADE OF 1980's									
Reduction of inventory	10	19	193	212	443	11	10	454	666
Replaced by growth	1,262	131	219	1,612	289	35	408	732	2,344
Salvage	71	3	2	74	110	2	26	138	212
All	1,333	153	412	1,898	842	48	434	1,324	3,222
DECADE OF 1990's									
Reduction of inventory	165	28	155	348	489	4	38	531	879
Replaced by growth	1,263	136	167	1,566	264	39	376	679	2,245
Salvage	61	1	1	63	102	1	25	128	191
All	1,489	165	323	1,977	855	44	439	1,338	3,315

¹ Cut does not exceed growth and hence does not reduce inventory.

² Less than 1/2 million board feet.

Table 53. — Prospective annual output of timber in the Columbia River district if present trends continue, by decade, ownership class, and source of output, 1960-2000

(In million board feet)

DECADE OF 1960's

Source of output	Private holdings				Public holdings				All holdings
	Large	Medium	Small	Total	National Forest	Other Federal	Other	Total	
Reduction of inventory	318	373	921	1,612	941	234	¹	1,175	2,787
Replaced by growth	1,532	61	461	2,054	563	235	281	1,079	3,133
Salvage	139	22	13	174	124	39	18	181	355
All	1,989	456	1,395	3,840	1,628	508	299	2,435	6,275

DECADE OF 1970's

Reduction of inventory	45	233	543	821	727	236	¹	963	1,784
Replaced by growth	1,812	81	384	2,277	781	250	299	1,330	3,607
Salvage	149	7	²	156	153	35	8	196	352
All	2,006	321	927	3,254	1,661	521	307	2,489	5,743

DECADE OF 1980's

Reduction of inventory	¹⁰	169	420	589	786	200	¹⁰	986	1,575
Replaced by growth	2,004	73	275	2,352	726	288	339	1,353	3,705
Salvage	105	5	1	111	190	35	11	236	347
All	2,109	247	696	3,052	1,702	523	350	2,575	5,627

DECADE OF 1990's

Reduction of inventory	275	25	126	426	618	269	¹⁰	887	1,313
Replaced by growth	1,951	144	317	2,412	933	234	359	1,526	3,938
Salvage	90	1	²	91	156	28	7	191	282
All	2,316	170	443	2,929	1,707	531	366	2,604	5,533

¹ Cut does not exceed growth and hence does not reduce inventory.

² Less than 1/2 million board feet.

Table 54. — Prospective annual output of timber in Southwest Oregon if present trends continue, by decade, ownership class, and source of output, 1960-2000

(In million board feet)

Source of output	Private holdings				Public holdings				All holdings
	Large	Medium	Small	Total	National Forest	Other Federal	Other	Total	
Reduction of inventory	723	118	389	1,230	339	347	54	740	1,970
Replaced by growth	463	22	77	562	230	206	10	436	998
Salvage	111	12	2	125	52	72	5	129	254
All	1,297	152	468	1,917	621	625	59	1,305	3,222
DECADE OF 1970's									
Reduction of inventory	487	70	192	749	358	335	18	710	1,459
Replaced by growth	427	23	48	498	219	233	37	490	988
Salvage	59	3	--	62	73	81	5	159	221
All	973	96	240	1,309	650	649	60	1,359	2,668
DECADE OF 1980's									
Reduction of inventory	92	33	74	199	361	258	35	654	853
Replaced by growth	658	11	49	718	228	321	24	573	1,291
Salvage	24	²	--	24	77	97	5	179	203
All	774	44	123	941	666	676	64	1,406	2,347
DECADE OF 1990's									
Reduction of inventory	34	³ 0	³ 0	34	314	355	31	700	734
Replaced by growth	822	40	76	938	293	238	35	566	1,504
Salvage	13	1	--	14	104	78	6	188	202
All	869	41	76	986	711	671	72	1,454	2,440

¹ Assumed withdrawal of forest land from commercial use causes inventory reduction to exceed timber cut.

² Less than 1/2 million board feet.

³ Cut does not exceed growth and hence does not reduce inventory.

PROSPECTIVE AGE-CLASS DISTRIBUTION

PRIVATE HOLDINGS IN THE PUGET SOUND DISTRICT

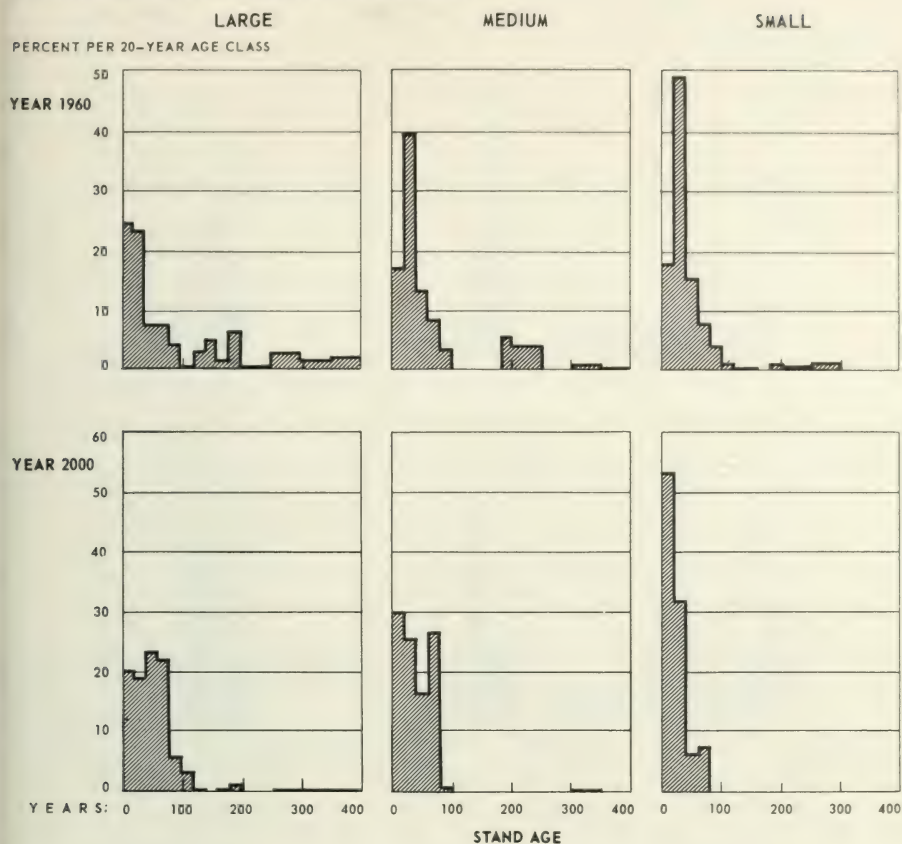


Figure 19.—Distribution of even-aged coniferous commercial forest area by stand-age class for major classes of private ownership, Puget Sound district, 1960 and 2000, if present trends continue.

PROSPECTIVE AGE-CLASS DISTRIBUTION

PUBLIC HOLDINGS IN THE PUGET SOUND DISTRICT

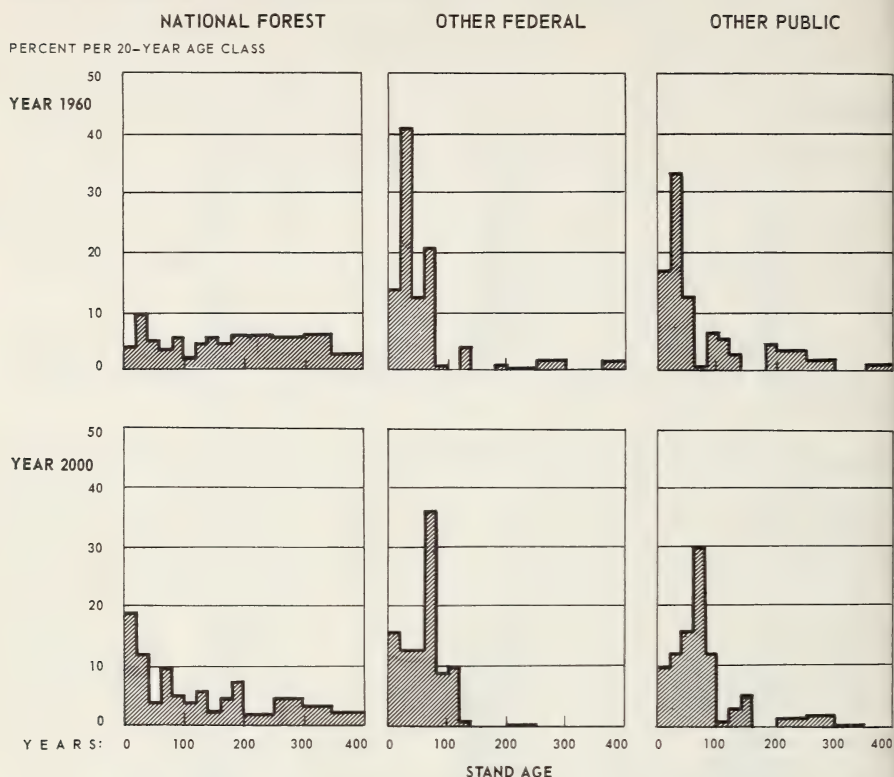


Figure 20.—Distribution of even-aged coniferous commercial forest area by stand-age class for major classes of public ownership, Puget Sound district, 1960 and 2000, if present trends continue.

PROSPECTIVE AGE-CLASS DISTRIBUTION

PRIVATE HOLDINGS IN THE COLUMBIA RIVER DISTRICT

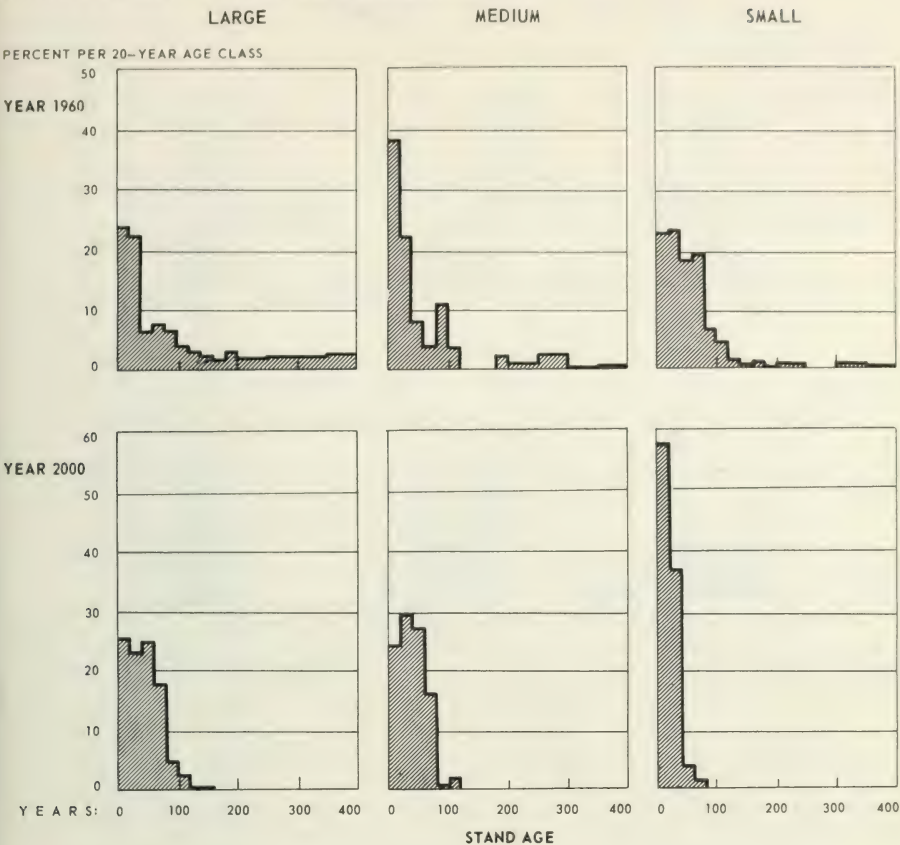


Figure 21.—Distribution of even-aged coniferous commercial forest area by stand-age class for major classes of private ownership, Columbia River district, 1960 and 2000, if present trends continue.

PROSPECTIVE AGE-CLASS DISTRIBUTION

PUBLIC HOLDINGS IN THE COLUMBIA RIVER DISTRICT

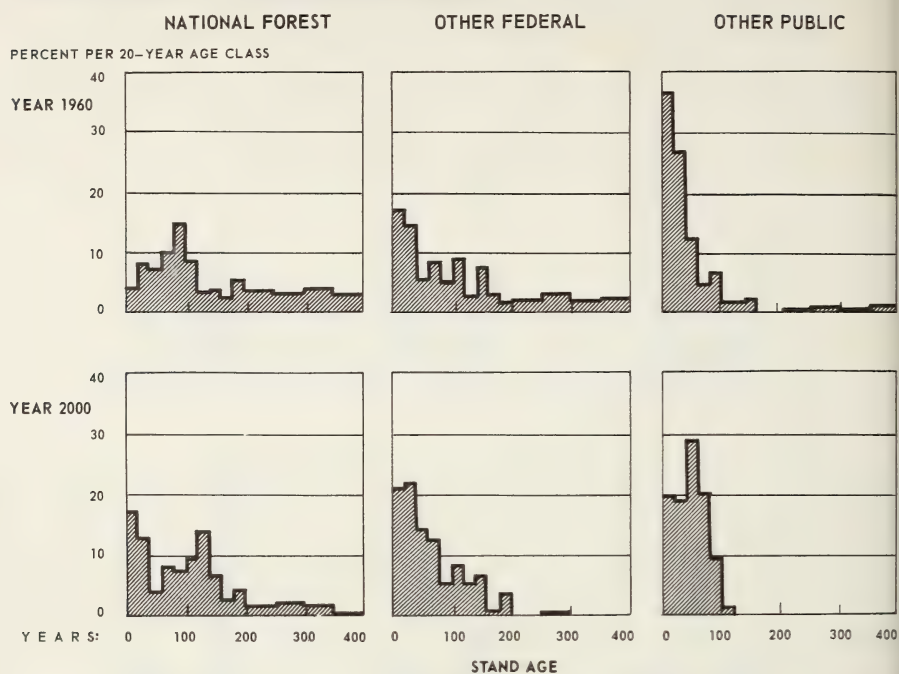


Figure 22.—Distribution of even-aged coniferous commercial forest area by stand-age class for major classes of public ownership, Columbia River district, 1960 and 2000, if present trends continue.

PROSPECTIVE AGE-CLASS DISTRIBUTION

PRIVATE HOLDINGS IN SOUTHWEST OREGON

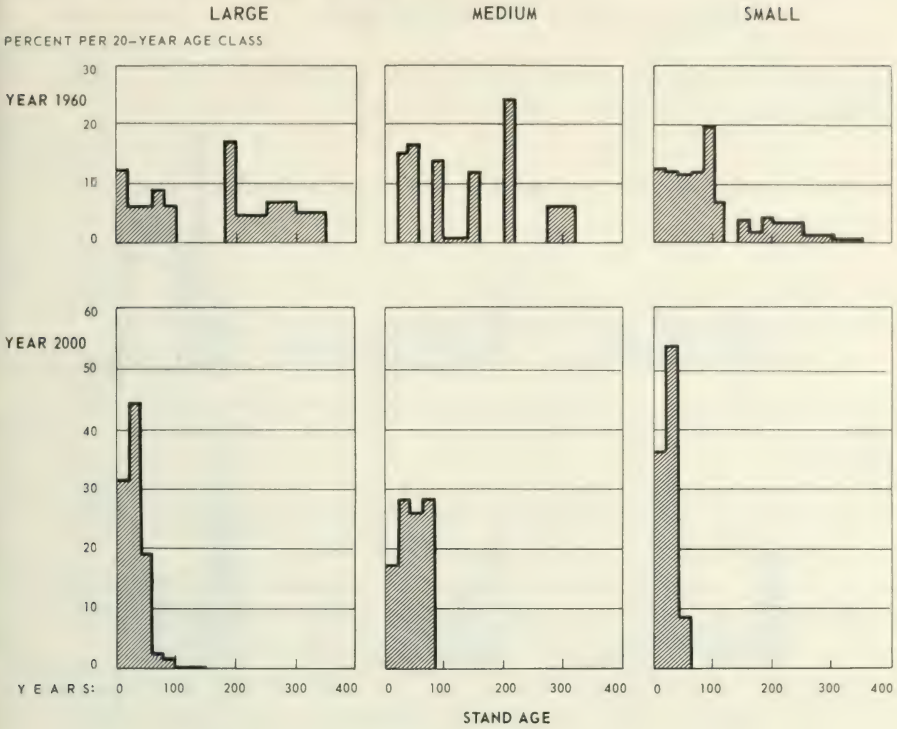


Figure 23.—Distribution of even-aged coniferous commercial forest area by stand-age class for major classes of private ownership, Southwest Oregon district, 1960 and 2000, if present trends continue.

PROSPECTIVE AGE-CLASS DISTRIBUTION

PUBLIC HOLDINGS IN SOUTHWEST OREGON

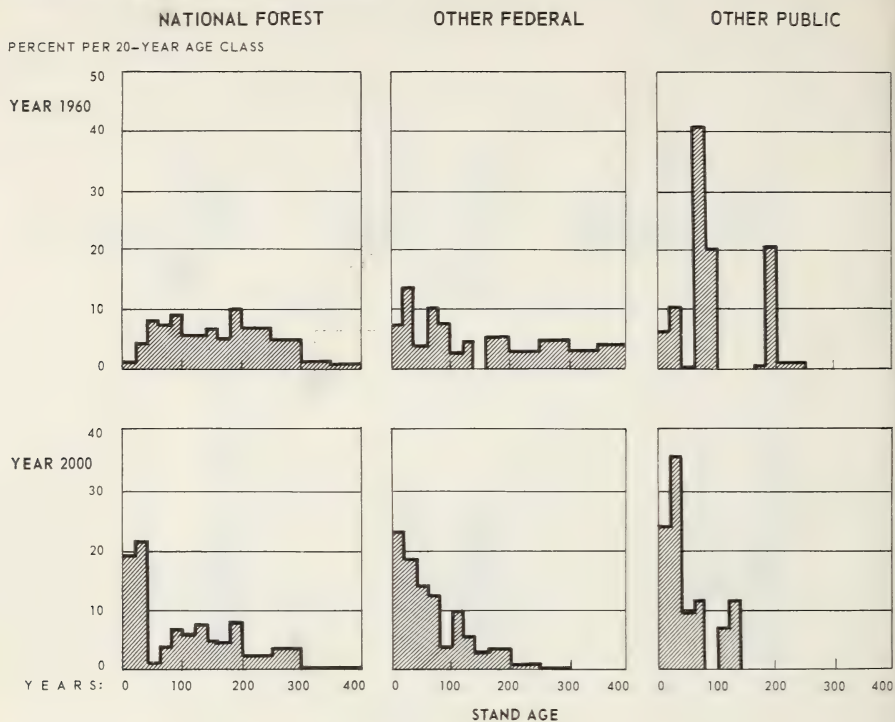


Figure 24.—Distribution of even-aged coniferous commercial forest area by stand-age class for major classes of public ownership, Southwest Oregon district, 1960 and 2000, if present trends continue.

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An economic analysis is made of the timber production potential of the Douglas-fir subregion of western Oregon and western Washington. Projections of cut and growth are applied to the timber inventory of the 1950's to trace future development of the resource under various assumptions concerning trends in forest ownership, protection, cutting programs, and reforestation. The economic model, the projection procedure, and the inventory now and in the future are described in detail.

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